PROCEEDINGS

AND

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

VOL. VII.

SESSION 1892—93.

LIVERPOOL:
PRINTED BY T. DOBB & Co., 229, BROWNLOW HILL.

1893.

ERRATA.

On p. xx, line 6 from foot for "Dames's" read "Steinman and Döderlein."

On p. 185, line 27 for "11" read "2."

,, p. 202, line 7 for "xxiii" read "xxii."

,, p. 203, line 31 for "xxxiii" read "xxiii."

,, p. 204, lines 2, 6, 10, 27 for "xxxiii" read "xxiii."

,, p. 204, line 18 for "xxxii" read "xxiii."

,, p. 211, line 1 for "xxv" read "xxvi."

CONTENTS.

I. Proceedings.

II. Transactions.

PROCEEDINGS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

OFFICE-BEARERS AND COUNCIL.

Ex-Presidents:

1886—87 Prof. W. MITCHELL BANKS, M.D., F.R.C.S.
1887—88 J. J. DRYSDALE, M.D.
1888—89 Prof. W. A. HERDMAN, D.Sc., F.R.S.E.
1889—90 Prof. W. A. HERDMAN, D.Sc., F.R.S.E.
1890—91 T. J. MOORE, C.M.Z.S.
1891—92 T. J. MOORE, C.M.Z.S. A.L.S.

SESSION VII, 1892-93.

President:

ALFRED O. WALKER, J.P., F.L.S.

Vice-Presidents:

Professor W. A. HERDMAN, D.Sc., F.R.S.
JOHN NEWTON, M.R.C.S.

Hon. Treasurer:

ISAAC C. THOMPSON, F.L.S., F.R.M.S.

Hon. Librarian:

R. HANITSCH, Ph.D.

Hon. Secretary:

JOSEPH A. CLUBB.

Council:

R. A. DAWSON.
J. W. ELLIS, M.B. (Vict.), F.E.S.
R. J. HARVEY GIBSON, M.A., F.L.S.
Prof. FRANCIS GOTCH, F.R.S.
W. J. HALLS.
J. SIBLEY HICKS, M.D., F.L.S.
C. H. HURST, Ph.D.
ALFRED LEICESTER.
J. LOMAS, Assoc. N.S.S.
G. H. MORTON, F.G.S.
W. NARRAMORE, F.L.S.
THOS. C. RYLEY.

REPORT of COUNCIL.

During the Session 1892—93 there have been eight ordinary meetings of the Society, held as heretofore at University College, and one field meeting in June, 1893. This year the society held the Field Meeting at Raby Mere, in place of Hilbre Island.

The communications made to the Society have been representative of almost all branches of Biology, and many interesting exhibits (both microscopic and macroscopic) have been submitted at the meetings.

The Library still continues to make satisfactory progress as shown by the Librarian's Report which follows.

The Treasurer's usual statement and Balance Sheet are appended.

No alterations have been made in the laws of the Society during the past session.

The members at present on the roll are as follows :—

Honorary Members.........	8
Ordinary Members..........	65
Student Members...........	23
Total	96

After careful consideration by the Council, it was decided at the January meeting that short obituary notices of any deceased members who have taken a specially prominent part in the affairs of the Society should be drawn up and inserted in the "Proceedings" for the year. In accordance with that resolution the following paragraphs in regard to our late members, Mr. F. Archer, Dr. Drysdale, and Mr. T. J. Moore, are here inserted. We are indebted to the courtesy of the Editors of the "The Naturalist" for the use of the portrait blocks of Mr. Archer and Mr. Moore on pp. ix and xiv.

FRANCIS ARCHER, B.A.

In Mr. F. Archer this Society, and Science in general in Liverpool, has lost one of the most widely cultured as well as one of the most earnest and enthusiastic of Naturalists. His father was Francis Archer, a surgeon who had come from Belfast to settle in Liverpool, and was well known, like his son, for his interest in the Natural Sciences. Frank Archer was born in 1839, educated at

For the accompanying portrait of Mr. F. Archer we are indebted to the kindness of the Editors of the "Naturalist" where the cut appeared in April, 1892, in an "In Memoriam" notice by Mr. Mellard Reade.

the Collegiate Institution in Shaw Street, and then at Trinity College, Cambridge, where he was a scholar, and took his degree with honours in 1862. By profession he was a solicitor, but, in addition to science and music, he took a great interest and an active part in politics and journalism, and was for a short time sub-editor of the Liverpool Daily Post. Even after he had gone back to the Law he continued to write occasionally for that paper and of late years reviews by him of scientific works have appeared from time to time in its columns. His deepest interest, however, was probably in Natural Science for which he had a keen love and unbounded enthusiasm. He had been a consistent evolutionist from the first appearance of the "Origin of species," was always ready to discuss theoretical points, and was delighted with any novel examples of variation, or mimicry which he came across, or any other striking illustrations of Darwinian views. He more than once expressed to the writer his astonishment that comparatively so few people read Darwin's works and that still fewer would take the trouble to thoroughly understand his meaning.

Archer was interested in, and worked, not merely as a student but as a contributor to our knowledge, at Geology, Prehistoric Archæology, Entomology, and Conchology; and he made collections in all these departments of Natural Science. He made various holiday excursions for the purpose of exploring for prehistoric remains of man, and he read several papers before the Liverpool Geological Society on flint implements from the North of Ireland and elsewhere. His collection of shells was most extensive. Partly inherited from a relation, largely added to by the dredgings sent home by his brother Surgeon-Colonel S. Archer from various foreign stations, this collection of Mollusca owes much to the loving care and constant

industry of F. Archer in collecting, identifying and arranging the contents of the cabinets.

Mr. Archer was one of the original members of the Liverpool Marine Biology Committee, and took an active part in the establishment of the Biological Station at Puffin Island and in the subsequent dredging expeditions, during which his special province was to look after the Mollusca obtained. He was to have been one of the small deputation from the L.M.B.C. who went to the Isle of Man on March 5th, 1892, to examine and report upon a suitable locality in which the Biological Station (now at Port Erin) might be erected. We heard of his sudden illness at the end of February, and a few days after of his death. Only a couple of days before his illness he had been working at the Norwegian Mollusca of the "Argo" collection at University College, and his unfinished lists were found and utilized in the Report which appeared in the sixth volume of our "Transactions." His Supplementary Report on the L.M.B.C. Mollusca, which he had been working at during the winter, was so nearly completed that it had been announced to be read before this Society at the March meeting. The lists and notes have since been edited by Mr. Brockton Tomlin, and the Report appeared in volume III of the "Fauna of Liverpool Bay," published in July, 1892.

Mr. Archer was a prominent member of Council of the Society, and one whom we had naturally looked forward to having as our President at no distant date; his ready and helpful sympathy, his kindly criticism, and his sturdy common sense will for long be greatly missed at all our biological gatherings, at the evening meetings and on the collecting expeditions.

[W.A.H.]

J. J. DRYSDALE, M.D.

John James Drysdale, M.D., who died August 20th, 1892, aged 75 years, was the second President of the Society and from its commencement one of its most earnest members and a very regular attender at its meetings.

A son of Sir William Drysdale at one time Lord Provost of Edinburgh and a member of an old Aberdeenshire family, Dr. Drysdale matriculated at the University of Edinburgh having chosen the Medical Profession for his career in life. Having completed the ordinary curriculum and passed through the University with distinction, Drysdale graduated as M.D. in 1838 being admitted a Licentiate of the College of Surgeons during the same year. He had been a pupil of Dr. Fletcher well known as a successful lecturer and physiologist and whose teachings led Drysdale to a study of homœopathy, seeing in it corroborative evidence of some physiological speculations of his own. With this end in view he spent some time in Vienna where he became acquainted with some of the homœopathic physicians of the city and was induced to give homœopathy that further practical investigation to which the teaching of Fletcher had predisposed him. After returning home, Dr. Drysdale selected Liverpool as a sphere for practice. He was then thoroughly assured that in homœopathy lay the scientific basis of therapeutics and which system he most successfully practiced to the close of his life; and he was from its foundation the senior consulting physician of the Liverpool Hahnemann Hospital.

But it is as a Biologist that we must here chiefly speak of him. Almost his first literary work amid the cares of a large practice was his editing of Fletcher's "Elements of General Pathology." In 1874 he published "The Protoplasmic Theory of Life," and during the same

and succeeding years in conjunction with Rev. Dr. Dallinger he wrote a series of original papers on "The Life-history of Monads." These last essays were the result of remarkably careful and continuous microscopical work and attracted much attention in the scientific world from the light they threw on the mode of development and propagation of these minute organisms.

In 1878 he issued "The Germ Theory of Infectious Diseases," anticipating in the application of his argument to practical medicine much of the work that Pasteur has since carried out. In his Presidential Address to this Society he took as his subject "The Definition of Life as affected by the Protoplasmic Theory," reviewing the theories of Fletcher, John Brown, Herbert Spencer, Beale, and others, and giving as a concise simplified definition "Life is the interaction of protoplasm with the environment."

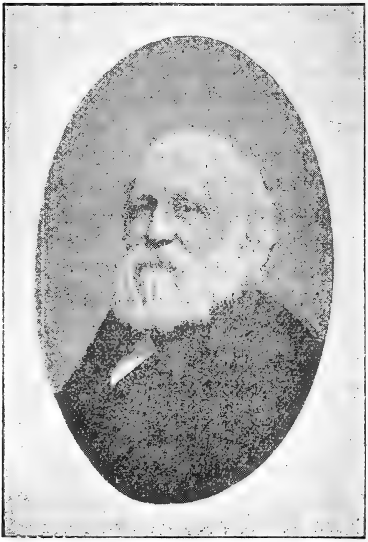
In Prof. Herdman's scheme for investigating the Fauna and Flora of Liverpool Bay, Dr. Drysdale took a warm and active interest and was a frequent attender of the various expeditions of the Liverpool Marine Biology Committee.

[I.C.T.]

T. J. MOORE, A.L.S.

Thomas John Moore, A.L.S., late President of this Society, was born in London in 1824. He belonged to an old Norfolk family and his father was connected with the Zoological Society of London for many years. Mr. Moore when a youth was also associated with that Society, but in 1843, at the age of nineteen, he came to Liverpool and was engaged as assistant to Mr. John Thompson, curator of the Natural History Collection at Knowsley, formed by the 13th Earl of Derby from 1836 to 1851. On the death of the Earl in the latter year the Derby Collection was

bequeathed to the Corporation of Liverpool for the benefit of the town, and Mr. Moore was appointed curator of the Free Public Museum, an office he held for more than forty years with great credit to himself and the respect of all who knew him. It was under his management that the Museum developed from the comparatively small beginning in Duke Street in 1853, to the splendid collections of Natural History and Antiquities in William



Brown Street, which have been enriched by gifts and the purchase of specimens from all parts of the world.

Mr. Moore will be principally remembered in connection with the Liverpool Museum, for it brought him in frequent contact with the most distinguished Naturalists, and his enthusiasm was well known and widely acknowledged. He was a member of most of the local scientific societies of Liverpool, and communications from him may be found in the "Proceedings" of the Literary and Philosophical and Geological Societies, and in the "Transactions" of the Historic and Biological Societies. Many years ago he was elected a Corresponding Member of the Zoological Society, and in 1892 an Associate of the Linnean Society. Mr. Moore made great and very successful efforts to induce captains of vessels to collect and bring home marine specimens. He was one of the original members of the Biological Society, and was a member of the Council continuously from its foundation to his death.

His courtesy to all visitors to the Free Public Museum and kindness to those seeking information will long be remembered, and he created many friends by the interest he evinced in their work. Mr. Moore's health began seriously to decline about six months before his death, and he then retired from the Museum. In October last (1892) he became worse, and died on the 31st of that month. His remains now rest in the burial ground attached to the Parish Church at Knowsley, near to the Hall where some of his most happy days were spent.

[G.H.M.]

SUMMARY of PROCEEDINGS at the MEETINGS.

The first meeting of the seventh session was held at University College on Friday, 14th October, 1892, Mr. A. O. Walker, President, in the chair.

1. The Report of the Council on the Session 1891-92 (see "Proceedings," Vol. VI, p. viii) was read and adopted.
2. The Treasurer's Balance Sheet for the Session 1891-92 (see "Proceedings," Vol. VI, p. xxx) was submitted and approved.
3. The Report of the Librarian (see "Proceedings," Vol. VI, p. xxvi) was submitted and approved.
4. The following Office-bearers and Council for the ensuing session were elected :—Vice-Presidents, Professor W. A. Herdman, D.Sc., F.R.S.; John Newton, M.R.C.S.; Hon. Treasurer, I. C. Thompson, F.L S., F.R.M.S.; Hon. Librarian, R. Hanitsch, Ph.D.; Hon. Secretary, Joseph A. Clubb; Council, R. A. Dawson, J. W. Ellis, M.B. (Vict.), F.E.S., R. J. Harvey Gibson, M.A., F.L.S., Professor F. Gotch, M.A., F.R.S., W. J. Halls, C. H. Hurst, Ph.D., Alfred Leicester, J. Lomas, Assoc. N.S.S., T. J. Moore, Corr. M.Z.S.L., A.L.S., G. H. Morton, F.G.S., W. Narramore, F.L.S., and T. C. Ryley.
5. The President (A. O. Walker, F.L.S.) then gave his Inaugural Address, on "the Fisheries of Flintshire and Denbighshire" (see "Transactions," this volume, p. 1). A vote of thanks to the President proposed by Prof. Herdman, and seconded by Mr. Ascroft was carried unanimously.

The second meeting of the Society was held at University College on Friday, 11th November, 1892, Prof. Herdman, Vice-President, in the chair.

1. Sympathetic reference was made from the chair, to the death of Mr. T. J. Moore, an Ex-President of the Society, and a member from its commencement.
2. Prof. Herdman brought before the Society a new case of Protective Colouring, observed by him, when dredging in Loch Fyne in the previous summer. (See "Transactions," p. 45, and Pl. VI).
3. Mr. P. F. J. Corbin exhibited a kitten with supernumerary toes, it having seven on each of the fore feet, and five on each of the hind feet.
4. Mr. W. E. Sharp read a paper on "the occasional phenomenal abundance of certain forms of Insect Life." (See "Transactions," p. 17).
5. Mr. J. S. Macdonald, B.A., exhibited some microscopic preparations showing mitotic figures in cells of the tail of a newt, and described briefly the method of preparation.
6. Some water-colour sketches of British Compound Ascidians, drawn by Miss A. E. Warham, B.Sc., were exhibited.
7. Prof. Herdman brought before the Society a proposal that a British Marine Fauna should be compiled. (See "Transactions," p. 248)

The third meeting of the Society was held at University College on Friday, 9th December, 1892, Mr. A. O. Walker, President, in the chair.

1. Mr. W. E. Hoyle exhibited with remarks specimens of *Nautilus pompilius*, and *Notoryctes typhlops* the mole-like Marsupial.
2. A paper by Miss A. E. Warham, B.Sc., on "Variations

in the Dorsal Tubercle of *Ascidia virginea* was communicated by Prof. Herdman. (See "Transactions," p. 98).

3. Prof. Herdman laid before the Society his Annual Report on the work of the Liverpool Marine Biology Committee, and the establishment of the Port Erin Biological Station. (See "Transactions," p. 45). The report was illustrated by lantern slides and specimens.

4. Prof. Gotch, F.R.S., read a paper on the Microscopic Structure of Insects' Muscle. He set forth the recent researches of Rollett, Ramón y Cajal, Schäfer and others on the structure of the cross striated fibres in the wing muscles of Insects. The paper was illustrated by lantern slides and microscopic preparations.

The fourth meeting of the Society was held in University College on Friday, 13th January, 1893, Prof. Herdman, Vice-President, in the chair.

1. Prof. Herdman announced that a tank room was in course of erection at the Port Erin Biological Station.

2. Professor H. A. Strong read a paper on the past history of the Rat and the Cat as illustrated by the evidence of language and literature. He shewed that there was no word for rat in either Latin or Greek: that the Slavonic nations gave the name properly applying to a mole to the recently imported rat: that the Italians while reserving the word of learned formation *talpa* for the mole, applied the popular form of talpa, (topo) to the rat: that the modern Greeks call the rat the Pontic Mouse: that all the Celtic nations each in their own dialect call the rat

the French mouse. The testimony of language then seems to be that the rat came (possibly shortly after the Christian Era) into Europe from the East, and judging by the fact that *ratte*, the Low German form of the word has become the classical German word for rat, it seems natural to suppose that the animals in question made their way along the Baltic. They were of course the old English Black Rats, evidently described by Amyntas as common on the Caspian Sea. Cats were unknown in Europe till about 300 B.C. and were evidently introduced into Europe from Egypt, probably to meet the newly imported pest of rats. Proofs were given that weasels or mungooses were the regular ancient substitute for cats; and even the name *felis* seems to be etymologically connected with an old word which alike in German and in Celtic signifies a weasel. A description was given from old writers on Egypt of the different uses to which Cats were put in Ancient Egypt.

3. Mr. F. W. Gamble, B.Sc., read a Report on the Turbellaria of Liverpool Bay. (See "Transactions," p. 148).
4. Mr. J. Lomas exhibited with remarks some very good specimens of fossil plants from St. Helens.

The fifth meeting of the Society was held at University College on Friday, 10th February, 1893, Prof. Herdman, Vice-President, in the chair.

1. Prof. Solms-Laubach of the Botan. Institut, Strassburg, proposed by R. J. Harvey Gibson, seconded by T. C. Ryley, was unanimously elected an Honorary Member of the Society.
2. Prof. Herdman exhibited some wasp's nests from the

South of England in which a number of flies were found to be hibernating.

3. Mr. Paden reported that a Dolphin (*Delphinus delphis*) had been stranded near West Kirby, in the Dee Estuary.

4. Mr. W. S. Henderson exhibited with remarks, some marine specimens collected by himself at the Canary Islands, and Mr. R. J. Harvey Gibson described some of the Algæ.

5. Mr. R. J. Harvey Gibson brought forward a proposal that the Cryptogamic Flora of the Liverpool District should be worked up, and invited the cooperation of other Botanists in the Society. The proposal was favourably received, and remarks and suggestions were made by Messrs. Narramore, Birks and others.

6. Dr. Hurst read a note "on the wings of *Archaeopteryx* and of recent birds," as follows :—

It is customary to regard the three easily-recognisable digits in a recent bird's wing as representing the first, second and third digits of the typical pentadactylous hand, though some writers regard them as representing the second, third and fourth.

In the Berlin specimen of *Archaeopteryx* (of which a photograph was exhibited) three free digits are seen and these are—it was considered—*obviously* fitted for climbing but far too slender to support a wing of such size as that seen in the same specimen. It was pointed out that the Dames's figure which is reproduced in several modern textbooks is inaccurate as to the position of the feathers of the wing, the terminal feathers making a smaller angle with the digits in his figure than in the actual specimen. Hence the conclusion that the bones which really

supported the primary quills of the wing are not seen on the surface of the specimen but still lie embedded in the slab. This conclusion is supported, first by the indication (by a shadow in the photograph) of a ridge on the slab corresponding in position with metacarpals similar in size to those which support the feathers of an ordinary bird's wing, and the same conclusion is more forcibly supported by the fact that such bones are actually visible in the London specimen and were figured by Owen in the Philosophical Transactions of the Royal Society thirty years ago.

From this conclusion, if it can be established by careful excavation of the Berlin slab—perhaps from the back—it will follow that the three digits of the recent bird's wing are the third, fourth and fifth; a view which does not appear to be opposed to anything which is known of the comparative anatomy or embryology of the wings of existing birds, with the sole exception of an observation by W. K. Parker which the writer professed himself unable to verify. Dr. Hurst's remarks were illustrated by lantern slides.

7. Mr. I. C. Thompson laid on the table his Revision of the Copepoda of Liverpool Bay. (See "Transactions," p. 175).

The sixth meeting of the Society was held at University College on Friday, 10th March, 1893.

1. Mr. H. C. Beasley exhibited with the lantern photographs of the series of footprints in Triassic Sandstone now in the Bootle Free Museum. The slabs bearing the footprints were originally in the Royal Institution, but some years ago were removed with

other things to the Bootle Free Museum, and have lately been placed in an excellent position where they have the advantage of a good light, and the Museum Committee kindly allowed Mr. Beasley to have them photographed. There is reason for believing that these are the original specimens described by Messrs. Cunningham and Yates and they are much finer than any thing that has been obtained of late years. The most important is one showing three impressions of the hind feet and two of the fore feet of the *Cheirotherium stortonense* from Storeton, and may be compared with a somewhat similar slab from Saxony. Mr. Beasley remarked on the apparent position of the hallux on the outer side of the foot of the Cheirotherium which might be accounted for by the feet being slightly crossed in walking.

2. Mr. Herbert C. Chadwick read a paper on the Hæmal and Water-vascular Systems of the Asteroidea. (See "Transactions," p. 231). The paper was illustrated by lantern slides.
3. Mr. R. J. Harvey Gibson gave an interesting account of the Botanische Institut, Strassburg, and exhibited photographs of the buildings.
4. Prof. Herdman laid on the table the Report of the work done in the Fisheries Laboratory for the year 1892. (See "Transactions," p. 100).

The seventh meeting of the Society was held at University College on Friday, 14th April, 1893, Mr. A. O. Walker, President, in the chair.

1. Miss F. Phillips exhibited with a description, specimens and drawings of *Alpheus affinis*, and *Palinurus vulgaris*, showing the structure of the sound producing organs of these Crustacea.

2. Mr. P. F. J. Corbin gave an interesting account of the spawning and spawning grounds of fishes in this neighbourhood. A short discussion followed to which Messrs. Thompson and Leicester and Dr. Ellis contributed.
3. A short note on *Pyrosoma* by Mr. W. Garstang, M.A., was communicated by the Hon. Secretary in the absence of the author. (See "Transactions," p. 245).
4. Mr. R. J. Harvey Gibson communicated an interesting paper by Mrs. Solly on "a Botanical Excursion to Van Staden, Cape of Good Hope," in which some of the more interesting plants of that country were described.

The eighth meeting of the Society was held at University College on Friday, 12th May, 1893, Prof. Herdman, Vice-President, in the chair.

1. Dr. Hanitsch exhibited some microscopic slides illustrating the structure and development of the Vertebrate Eye.
2. Dr. Hurst gave a paper entitled "A Criticism of the Recapitulation Theory," of which the following is the author's abstract:—A close resemblance between the ontogenetic and the phylogenetic series has been observed in very few cases and in these the parallelism is accidental. The vast majority of ontogenetic series are unlike the corresponding phylogenetic series, and any partial resemblance between them is accidental. Von Baer's "law" is proved for many cases by the personal observation of every student who compares a *series* of vertebrate embryos of one species with similar series belonging to other species. This partial appli-

cability of von Baer's "law" is incompatible with the truth of the statement that successive stages in a single ontogeny form "records"—even "imperfect records"—of successive stages of the phylogeny of the same species.

Clues to the affinities of the Rhizocephala have been obtained from the study of their ontogenies: and larval (or embryonic) structure may be expected to give similar clues in other cases. The similarity of the nauplei of these animals to the nauplei of other crustaceans may justify the conclusion that the Rhizocephala are genetically related to the Crustacea, *i.e.* that Rhizocephala and Crustacea have descended from common ancestors, and even perhaps from common ancestors which passed through a nauplius-like stage in their development, but it does not justify the conclusion that those common ancestors (or any of them) possessed in their adult condition any single character which distinguishes a nauplius from any adult crustacean now living.

An interesting discussion followed in which Prof. Herdman, Mr. Lomas, Mr. I. C. Thompson and Dr. Hanitsch participated.

3. A note by Mr. W. J. Beaumont on Lucernarians found at Port Erin was communicated by Prof. Herdman. (See "Transactions," p. 253).

4. Dr. Hurst read a note on "a hypothetical explanation of the function and mode of action of the tentaculocysts of *Scyphomedusæ*" in which he explained that:—

The food of pelagic medusæ is confined to regions not far removed from the ocean-surface. In stormy weather a large medusa very near the surface

would be torn by the violence of the waves. The tentaculocysts form part of an apparatus by means of which the animal is automatically so steered that it shall never sink or swim to depths greater than those where food is obtainable, and shall never rise nearer to the surface than is safe. In calm weather they will be brought nearer to the surface than in rough weather. The mechanism of the apparatus was explained.

The ninth and last meeting of the Society for the Seventh Session took the form of a Field-Meeting to Bromborough, Dibbinsdale Woods and Raby Mere, on June 24th, 1893. Dr. Ellis kindly acted as guide, and an enjoyable afternoon was spent. After tea a short business meeting was held, Prof. Herdman in the chair, when on the motion of the Chairman, seconded by Dr. Ellis, and supported by Mr. W. J. Halls, Dr. John Newton, M.R.C.S., was elected President for the ensuing session.

LAWS of the LIVERPOOL BIOLOGICAL SOCIETY.

I.—The name of the Society shall be the "LIVERPOOL BIOLOGICAL SOCIETY," and its object the advancement of Biological Science.

II.—The Ordinary Meetings of the Society shall be held at University College, at Seven o'clock, during the six Winter months, on the second Friday evening in every month, or at such other place or time as the Council may appoint.

III.—The business of the Society shall be conducted by a President, two Vice-Presidents, a Treasurer, a Secretary, a Librarian, and twelve other Members, who shall form a Council; four to constitute a quorum.

IV.—The President, Vice-Presidents, Treasurer, Secretary, Librarian, and Council shall be elected annually, by ballot, in the manner hereinafter mentioned.

V.—The President shall be elected by the Council (subject to the approval of the Society) at the last Meeting of the Session, and take office at the ensuing Annual Meeting.

VI.—The mode of election of the Vice-Presidents, Treasurer, Secretary, Librarian, and Council shall be in form and manner following:—It shall be the duty of the retiring Council at their final meeting to suggest the names of Members to fill the offices of Vice-Presidents, Treasurer, Secretary, Librarian, and of four Members who were not

on the last Council to be on the Council for the ensuing session, and formally to submit to the Society, for election at the Annual Meeting, the names so suggested. The Secretary shall make out and send to each Member of the Society, with the circular convening the Annual Meeting, a printed list of the retiring Council, stating the date of the election of each Member, and the number of his attendances at the Council Meetings during the past session; and another containing the names of the Members suggested for election, by which lists, and no others, the votes shall be taken. It shall, however, be open to any Member to substitute any other names in place of those upon the lists, sufficient space being left for that purpose. Should any list when delivered to the President contain other than the proper number of names, that list and the votes thereby given shall be absolutely void. Every list must be handed in personally by the Member at the time of voting. Vacancies occurring otherwise than by regular annual retirement shall be filled by the Council.

VII.—Every Candidate for Membership shall be proposed by three or more Members, one of the proposers from personal knowledge. The nomination shall be read from the Chair at any Ordinary Meeting, and the Candidate therein recommended shall be balloted for at the succeeding Ordinary Meeting. Ten black balls shall exclude.

VIII.—When a person has been elected a Member, the Secretary shall inform him thereof, by letter, and shall at the same time forward him a copy of the Laws of the Society.

IX.—Every person so elected shall within one calendar month after the date of such election pay an Entrance Fee of Half a Guinea and an Annual Subscription of One

Guinea (except in the case of Student Members); but the Council shall have the power in exceptional cases, of extending the period for such payment. No Entrance Fee shall be paid on re-election by any Member who has paid such fee.

X.—The Subscription (except in the case of Student Members) shall be One Guinea per annum, payable in advance, on the day of the Annual Meeting in October.

XI.—Members may compound for their Annual Subscriptions by a single payment of Ten Guineas.

XII.—There shall also be a class of Student Members, paying an Entrance Fee of Two Shillings and Sixpence, and a Subscription of Five Shillings per annum.

XIII.—All nominations of Student Members shall be passed by the Council previous to nomination at an Ordinary Meeting. When elected, Student Members shall be entitled to all the privileges of Ordinary Members, except that they shall not receive the publications of the Society, nor vote at the Meetings, nor serve on the Council.

XIV.—Resignation of Membership shall be signified *in writing* to the Secretary, but the Member so resigning shall be liable for the payment of his Annual Subscription, and all arrears up to the date of his resignation.

XV.—The Annual Meeting shall be held on the second Friday in October, or such other convenient day in the month as the Council may appoint, when a Report of the Council on the affairs of the Society, and a Balance Sheet, duly signed by the Auditors previously appointed by the Council, shall be read.

XVI.—Any person (not resident within ten miles of Liverpool) eminent in Biological Science, or who may have rendered valuable services to the Society, shall be eligible

as an Honorary Member; but the number of such Members shall not exceed fifteen at any one time.

XVII.—Captains of vessels and others contributing objects of interest shall be admissable as Associates for a period of three years, subject to re-election at the end of that time.

XVIII.—Such Honorary Members and Associates shall be nominated by the Council, elected by a majority at an Ordinary Meeting, and have the privilege of attending and taking part in the Meetings of the Society, but not voting.

XIX.—Should there appear cause in the opinion of the Council for the expulsion from the Society of any Member, a Special General Meeting of the Society shall be called by the Council for that purpose; and if two-thirds of these voting agree that such Member be expelled, the Chairman shall declare this decision, and the name of such Member shall be erased from the books.

XX.—Every Member shall have the privilege of introducing one visitor at each Ordinary Meeting. The same person shall not be admissable more than twice during the same session.

XXI.—Notices of all Ordinary or Special Meetings shall be issued to each Member by the Secretary, at least three days before such Meeting.

XXII.—The President, Council, or any ten Members can convene a Special General Meeting, to be called within fourteen days, by giving notice in writing to the Secretary, and Stating the object of the desired Meeting. The Circular convening the Meeting must state the purpose thereof.

XXIII.—Votes in all elections shall be taken by ballot, and in other cases by show of hands, unless a ballot be first demanded.

XXIV.—No alteration shall be made in these Laws, except at an Annual Meeting, or a Special Meeting called for that purpose; and notice in writing of any proposed alteration shall be given to the Council, and read at the Ordinary Meeting, at least a month previous to the meeting at which such alteration is to be considered, and the proposed alteration shall also be printed in the circular convening such meeting; but the Council shall have the power of enacting such Bye-Laws as may be deemed necessary, which Bye-Laws shall have the full power of Laws until the ensuing Annual Meeting, or a Special Meeting convened for their consideration.

BYE-LAW.

Student Members of the Society may be admitted as Ordinary Members without re-election upon payment of the Ordinary Member's Subscription; and they shall be exempt from the Ordinary Member's entrance fee.

LIST of MEMBERS of the LIVERPOOL BIOLOGICAL SOCIETY.

SESSION 1892-93.

A. Ordinary Members.

(Life Members are marked with an asterisk.)

ELECTED.	
1890	Assheton, R., M.A., Owens College, Manchester
1888	Atkin, Hope T., Egerton House, Egerton Park, Rock Ferry
1886	Banks, Prof. W. Mitchell, M.D., F.R.C.S., 28, Rodney-street
1890	Batters, E. A. L., B.A., LL.B., F.L.S., The Laurels, Wormley, Herts
1886	Barron, Prof. Alexander, M.B., M.R.C.S., 31, Rodney-street
1888	Beasley, Henry C., Prince Albert-road, Wavertree
1892	Biddle, Leonard F., 21, Canning-street
1889	Brown, Prof. J. Campbell, 27, Abercromby-square
1887	Caine, Nathaniel, Spital, Bromborough
1886	Caton, R., M.D., F.R.C.P., Lea Hall, Gateacre
1886	Clubb, J. A., Hon. Secretary, University College, Liverpool
1892	Corbin, P. F. J., Fisheries Lab., Univ. College, Liverpool
1890	Davies, D., 55, Berkley-street
1890	Dawson, R. A., Roslyn, Lytham
1886	Dillcock, T., 8, Church-street, Egremont
1891	Dismore, Miss, 65, Shrewsbury-road, Oxton
1889	Dwerryhouse, A. R., Church-end Farm, Hale
1886	Ellis, J. W., M.B. (Vic.), F.E.S., 18, Rodney-st.

1890 Ewart, A. J., University College, Liverpool
1891 Garstang, W., M.A., Marine Biological Laboratory, Plymouth
1886 Glynn, Prof. T. R., M.D., F.R.C.P., 62, Rodney-street
1886 Gibson, R. J. Harvey, M.A., F.L.S., University College
1891 Gotch, Prof. F., F.R.S., University College
1886 Halls, W. J., 35, Lord-street
1887 Hanitsch, R., Ph.D., HON. LIBRARIAN, University College, Liverpool
1887 Healey, George F., Oakfield, Gateacre
1886 Herdman, Prof. W. A., D.Sc., F.R.S., VICE-PRESIDENT, University College
1891 Hicks, J. Sibley, M.D., 2, Erskine-street
1888 Hurst, C. H., Ph.D., Owens College, Manchester
1886 Jones, Charles W., Field House, Prince Alfred-road, Wavertree
1886 Leicester, Alfred, Priory Gardens, Birkdale
1886 Lomas, J., Assoc.N.S.S., Salen, Amery Grove, Birkenhead
1890 Lowndes, W., 173, Lodge-lane
1893 Macdonald, J. S., B.A., Physiological Lab. Univ. College, Liverpool
1888 Melly, W. R., 90, Chatham-street
1886 McMillan, William S., F.L.S., Brook-road, Maghull
1886 McClelland, Joseph, M.D., 7, Sefton-drive, Sefton Park
1886 Morton, G. H., F.G.S., 209, Edge-lane, E.
1888 Newton, John, M.R.C.S., VICE-PRESIDENT, 44, Rodney-street
1887 Narramore, W., F.L.S., 5, Geneva-road, Elm Park
1891 Phillips, Miss F., 3, Green-lawn, Rock Ferry
1892 Phillips, E. J. M., L.D.S., M.R.C.S., Rodney-st.

1888 Phillips, Prof. Reg. W., M.A., University College, Bangor
1886 *Poole, Sir James, J.P., Abercromby Square
1890 Rathbone, Miss May, Backwood, Neston
1890 Roberts, Leslie, M.B., 31, Rodney-street
1887 Robertson, Helenus R., Springhill, Church-road, Wavertree
1887 Ryley, Thomas C., 10, Waverley-road
1892 Sephton, Rev. J., M.A., 90, Huskisson-street
1881 Sharp, W. E., The Woodlands, Ledsham, Chester
1886 Smith, Andrew T., Jun., 13, Bentley-road, Prince's Park
1889 Stewart, W. J., B.A., Magistrates' Court, Dale-st.
1886 Thompson, Isaac C., F.L.S., F.R.M.S, Hon. Treasurer, Woodstock, Waverley-road
1889 Thornely, Miss L. R., Baycliff, Woolton Hill
1889 Thurston, Edgar, Gov. Central Museum, Egmont, Madras, India
1888 Toll, J. M., Kirby Park, Kirby
1886 Vicars, John, 8, St. Albans-square, Bootle
1886 Walker, Alfred O., J.P., F.L.S., President, Colwyn Bay
1889 White, P. H., M.B., University College, Bangor
1889 Williams, Miss Leonora, 55, Rocky-lane
1893 Williams, Henry, Jun., Gowan Brae, College-road, Gt. Crosby
1891 Wiglesworth, J., M.D., County Asylum, Rainhill
1891 Wood, G. W., F.I.C., Riggindale-road, Streatham, London
1892 Weiss, Prof., Owens College, Manchester
1892 Young, T. F., M.D., 12, Merton-road, Bootle

B. Student Members.

Armstrong, Miss A., 26, Trinity-road, Bootle
Armstrong, H., Stainsland, Spital, Cheshire

Buckley, Miss L., B.Sc., University College, Liverpool
Christophers, S. R., 10, Lily-road, Fairfield
Depree, S. S., 3, Morley-road, Southport
Dickinson, T., 3, Clark-street, Prince's Park
Dumergue, A. F., 7, Montpellier-terrace, Up. Parliament-st.
Dutton, J. E., Kings-street, Rock Ferry
Griffiths, A. S., Manor House, Hale
Gould, Joseph, Littledale-road, Egremont
Hannah, J. H. W., 8, Allington-street, Aigburth-road
Hamilton, A. G., 16, Whitefriars, Chester
Harding, Miss M., Kremlin-drive, West Derby
Hay, John, 92, Bridge-street, Birkenhead
Henderson, W. S., 2, Holly-road, Fairfield
Hurter, D. G., Holly Lodge, Cressington
Lovegrove, F. T. A., Marino, Blundellsands
Paden, R., Free Museum
Palethorpe, Miss F., 14, Sandon-street
Simpson, A. Hope, Annandale, Sefton Park
Stubbs, M. C., Wavertree Rectory
Warham, Miss A. E., B.Sc., 70, North-street, St. Andrews N.B.
Willmer, Miss J. H., Westbourne-road, Birkenhead

C. Honorary Members.

H.S.H. Albert I., Prince of Monaco, 25, Faubourg St. Honore, Paris
Bornet, Dr. Edouard, Quai de la Tournelle 27, Paris
Claus, Prof. Carl, University, Vienna
Fritsch, Prof. Anton, Museum, Prague, Bohemia
Giard, Prof. Alfred, Sorbonne, Paris
Haeckel, Prof. Dr. E., University, Jena
Marshall, Prof. A. Milnes, D.Sc., F.R.S., Manchester
Solms-Laubach, Prof. Dr., Botan. Instit., Strassburg

REPORT of the LIBRARIAN.

Our Society has arranged an exchange of publications with five additional societies since the last Report, making in all sixty-six societies.

The necessity for a bookcase having now been removed, the fund collected two years ago for the purpose of providing one has been applied to binding the volumes.

The following list gives the titles of the exchanges and donations received during the session:—

1. Académie des Sciences et Lettres de Montpellier. Sur les observations actinométriques faites pendant l'année 1887, etc. Mémoires de la Section des Sciences. T. XI.
2. Actes de la Société Scientifique du Chili. Tome II, Nos. 1—3.
3. Allgemeine Fischerei—Zeitung. XVIII, Nos. 1—13.
4. Annales du Musée d'Histoire Naturelle de Marseille. Tome III, (1886—89).
5. Annalen d. k.k. naturh. Hofmuseums, Bd. VII, Nos. 3 and 4. VIII, No. 1.
6. Transactions and Annual Report of the Manchester Microscopical Society.
7. Annual Report of the Board of Regents of the Smithsonian Institution. 1890—Report of the U.S. National Museum.
8. Tenth Annual Report of the Fishery Board for Scotland, 1891.
9. Sixteenth Annual Report of the Lancashire and Cheshire Entomological Society. Session 1892.
10. Archiv. des Vereins der Naturgeschichte in Mecklenburg. 45. Jahr (1891).
11. Archives Néerlandaises des Sciences exactes et naturelles. XXV, 5; XXVI; XXVII, 1 and 2.
12. Archives du Musée Teyler. Vol. IV, No. 1.
13. The Australian Museum. Report of the Trustees for the year 1891. Catalogue No. 15.
14. Berichte über die Verhandlungen d. Königl. Sächs. Gesellschaft. Leipzig. 1892, III—VI; 1893, I—III.
15. Berichte über die Senckenbergische naturforschende Gesellschaft in Frankfurt a. M. 1892. Katalog der Batrachier—Sammlung.

16. Berichte der naturforschenden Gesellschaft, Freiburg i. B. Vol. VI, Nos. 1—4.
17. Bergens Museums Aarsberetuing for 1891.
18. Bulletin of the Natural History Society of New Brunswick. Nos. 6—10.
19. Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. XVI, No. II; Vol. XXIII, Nos. 3, 4, 6; Vol. XXIV, Nos. 4—3 and Annual Report 1891—92.
20. Bulletin of the United States National Museum. No. 39, parts F. & G. No. 40. Special Bulletin of the United States National Museum. No. 1. (Life History of North American Birds. By Charles Bendire.)
21. Bulletin de la Société Impériale des Naturalistes de Moscou. 1892, Nos. 1—4; 1893, No. 1.
22. Bulletin Scientifique de la France et de la Belgique. XXIII and XXIV.
23. Bulletin de la Société Zoologique de France. Tome XVI, Nos. 9—10; Tome XVII, Nos. 1—8.
24. Bulletin de la Société des Sciences de Nancy. Ser. 2; Tome XI, and XII. Bulletin des Séances: Nos. 1, 2, 5, 7, 9.
25. Bolletino della Società Adriatica di Scienze naturali in Trieste. Vol. XIV.
26. Bolletino dei Musei di Zoologia ed Anatomia comparata. Torino. Nos. 127—150.
27. Catalogue of the British Echinoderms. By F. Jeffrey Bell.—General Guide to the British Museum.—Guide to the Galleries of Mammalia.—Guide to Sowerby's Models of British Fungi. Presented by the British Museum.
28. Deutcher Fischerei Verein. 1892, Circular 3—7.
29. Ergebnisse d. Beobachtungsstationen an den deutschen Küsten. 1891, IV—XII.
30. Fra der danske biologiske Station II, 1891.
31. Fortegnelse over de af det k. Videnskabernes Selskab, 1742—1891.
32. Journal Marine Biological Association. II, 4 and 5. III, 1.
33. Journal of the College of Science, Imperial University, Japan. Vol. V, part 2 and 3, Vol. VI, part 1.
34. Liverpool Science Students' Association. Annual Reports and Proceedings for Sessions 1890—91 and 91—92.
35. The Manchester Museum. Outline and Classification of the Vegetable Kingdom.—Outline and Classification of the Animal Kingdom.—Catalogue of the Type Fossils.
36. Mathemat. und naturw. Mittheilungen d. k. preuss. Akademie d. Wissenschaften, Berlin. May, 1892—May, 1893.
37. Memoire della R. Accademia delle Scienze dell' Instituto di Bologna, Serie V, Tomo 1.

38. Mémoires de la Société Zoologique de France. Tome IV. No. 5 ; Tome V, Nos. 1—5.
39. Nachrichten d. Königl. Gesellschaft der Wissenschaften zu Göttingen, 1892.
40. Natuurkundig Tijdschrift voor Nederlandsch—Indie. Deel LI.
41. The Naturalist. Monthly Journal of Natural History for the North of England. 1884—July 1893.
42. Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger. 1892, 1893, No. 1.
43. Proceedings of the Royal Physical Society. Session 1891—92.
44. Proceedings of the Birmingham Philosophical Society. Vol. VII, part 4 ; Vol. VIII, part 1.
45. Proceedings of the Royal Society of Edinburgh. Session 1890—91.
46. Proceedings and Transactions of the Nova Scotian Institute of Science. 2nd Series. Vol. I, part 1.
47. Proceedings of the Boston Society of Natural History. Vol. XXV.
48. Procès—Verbaux de la Société Linnéenne de Bordeaux. 1891—92.
49. Proceedings of the Academy of Natural Sciences of Philadelphia. 1892, part 2 and 3 ; 1893, part 1.
50. Proceedings of the United States National Museum. Nos. 890—898 ; 900 ; 903—915 ; 919, 920 ; 922—925.
51. Proceedings of the Royal Society of Victoria. Vol. IV (N.S,), part 1.
52. Reports from the Laboratory of the Royal College of Physicians, Edinburgh. Vol. IV.
53. Rendiconto dell' Accademia delle Scienze fisiche e matematiche di Napoli. Vol. VI, fasc. 6—12 ;Vol. VII, fasc. 1—5.
54. Report of the United States National Museum for 1890, pages 253—383.
55. Revue Biologique du Nord de la France, 1[re]—4[e] Année. 5[e] Année, Nos. 1 and 2.
56. Sitzungsberichte d. d. preuss. Akademie d. Wissenchaften zu Berlin. Nos. 1—55.
57. Scientific Proceedings of the Royal Dublin Society. Vol. VII (N.S.). Parts 3 and 4.
58. Scientific Transactions of the Royal Dublin Society. Vol. IV, Nos. X—XIII.
59. Spolia Atlantica. Scopelini Musei Zoologici Universitatis Hauniensis. By Dr. Chr. Fr. Lütken.
60. Studies from the Biological Laboratory, Johns Hopkins University, Baltimore. Vol. V, Nos. 2 and 3.
61. Transactions of the Canadian Institute. Vol. III, part 1.
62. Transactions of the Yorkshire Naturalists' Union. Parts 1—17.
63. Verhandlungen d. k.k. zoologisch—botanischen Gesellschaft in Wien. 1892, Nos. 3 and 4 ; 1893, Nos. 1 and 2.

64. Verhandlungen d. naturhist. Vereins d. preuss. Rheinlande. XLIX.
65. Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjobenhavn. 1892.
66. Vierteljahrschrift der Naturforschenden Gesellschaft in Zürich. 1887—1892; 1893 No. 1.—Neujahrsblatt 188, 1887, 1888, 1890, 1892, 1893.
67. Zeitschrift für Fischerei. Vol. I, Nos. 1—2.
68. Les Algues de P.—K.—A. Schousboe. By M. Edouard Bornet. Presented by the author.
69. British Association, Edinburgh, 1892. Address by Sir Archibald Geikie. Address to the Biological Section, by Prof. W. Rutherford. Report on the Marine Biological Association, Plymouth. Report on the Zoological Station, Naples. Presented by Prof. Herdman, F.R.S.
70. Eight Pamphlets on Helmintology. Presented by Prof. M. Stossich, Triest.
71. The Manchester Museum. Outline and Classification of the Vegetable Kingdom.
72. Vermi parassiti in animali della Croazia. By Michele Stossich.—Elminti della Croazia. By the same—Elminti Veneti. By the same—Osservazioni elmintologiche. By the same. Presented by the author.
73. The Climate of the North Coast of Wales. By Alfred O. Walker, F.L.S. Presented by the author.
74. I Tronchi di Bennettitee dei Musei Italiani. By G. Capellini and E. Solms-Laubach.—Die Sprossfolge der Stangeria und der übrigen Cycadeen. By E. Solms-Laubach. Die Organismen des Sauerteigs. By W. L. Peters.—Ueber die in den Kalksteinen des Kulm von Glätzisch — Falkenberg in Schlesien erhaltenen structurbildenden Pflanzenreste. By E. Solms-Laubach.—Beitrag zur Kenntniss der Gattung *Roxburghia*. By V. Lachner—Sandoval. Presented by H. Graf zu Solms-Laubach.
75. On some Marine Algæ from New Zealand. By R. J. Harvey Gibson, Esq., M.A., F.L.S. Presented by the author.
76. Animal Intelligence. By George J. Romanes. Presented by R. J. Harvey Gibson, Esq., M.A., F.L.S.
77. The Geographical and Geological Distribution of Animals. By Angelo Heilprin. Presented by R. J. Harvey Gibson, Esq., M.A., F.L.S.
78. Elements of the Comparative Anatomy of Vertebrates. Adapted from the German of R. Wiedersheim by W. Newton Parker. London: MacMillan and Co., 1886. Presented by R. J. Harvey Gibson, Esq., M.A., F.L.S.

THE LIVERPOOL BIOLOGICAL SOCIETY,

Dr. IN ACCOUNT WITH ISAAC C. THOMPSON, HON. TREASURER **Cr.**

1893.	£	s.	d.	1893.	£	s.	d.
To Use of Rooms, &c., University College	3	3	0	By Balance, June 30th, 1892	12	17	6
,, Tea and Attendance at Meetings	4	0	0	,, 7 Members' Entrance Fees at 10/6	3	13	6
,, Printing and Stationery, T. Dobb & Co.	46	17	6	,, 6 Student Members' Entrance Fees at 2/6	0	15	0
,, Carriage of Books and Reports	4	8	2	,, 61 Members' Subscriptions at 21/-	64	1	0
,, Postages	4	3	5	,, 19 Student Members' Subscriptions at 5/-	4	15	0
,, Bookbinding, Jeans & Co.	10	0	0	,, Donation by President	1	1	0
,, Balance in hand June 30th, 1893	32	18	8	,, Library Donations, Special	11	0	0
				,, Sale of Proceedings	5	12	9
				,, Sale of Urn and Tea things	1	15	0
	£105	10	9		£105	10	9

By Balance in Union Bank £32 18 8

ISAAC C. THOMPSON,
HON. TREASURER.

LIVERPOOL, *June 30th*, 1893.

Audited and found correct,

ALFRED LEICESTER.

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

OPENING ADDRESS:
THE FISHERIES OF FLINTSHIRE AND DENBIGHSHIRE.

By Alfred O. Walker, F.L.S., President.

[Read October 14th, 1892.]

The Report I propose to submit will deal principally with Fish in the proper sense of the word, with a few remarks on the so-called "fisheries" of Crustacea (Lobsters, Crabs, Shrimps and Prawns) and Mollusca (Mussels, Cockles, &c.). The area of which I propose to treat will comprise the River Dee and the coast to the westward as far as the Conway, including the rivers falling into the sea on that coast.

Fresh Water Fisheries.

First in importance among these fisheries is that of the Salmon, under which head will be included *Salmo salar* and *Salmo trutta* or Sea Trout, Salmon Trout, Buntling, Fork-tail, and Sewin—all of which I follow the late Mr. Day in referring to *S. trutta*. Beginning with the Dee, the highest part of the river where the fishing is carried on as a means of earning a livelihood is in the neighbourhood of Bangor Iscoed, and Overton. Higher up, the river is too shallow and rocky for the use of nets, and rod-fishing, which as a rule may be considered merely as a sport, is the only method of taking salmon. In the above named locality however it is fished for probably in much the same way as it was in the time of the Romans,

namely, by means of small draft nets worked by two men in "coracles"—small quadrangular boats made of tarpaulin stretched over a light wooden framework. The coracles float down the stream with the net stretched across it between them. When a fish strikes the net they encircle it and land it. From Overton down to below the "weir" at Chester is a long stretch of water unsuited to net fishing. From the old bridge at Chester down to a line drawn across from a rocky point (Rockliff) about one mile below Connah's Quay, to Bidston Point in Cheshire, the draught net alone is used. This is a net 200 yards long and 8 feet deep, having the "Act of Parliament" mesh of 2 in. from knot to knot, measured when wet, and furnished with a bag in the centre. It is worked by two men having a small row boat with a counter or small deck at the stern on which the net is piled. The net has a long rope attached to the top rope at one end and a shorter rope at the other. When used, one man rows the boat across the river, keeping the bow turned slightly to meet the tide so as to form the arc of a circle, while the other man remains on shore and holds the shorter rope so that the net falls into the water as the boat proceeds. When all the net has left the boat the rower turns towards the shore which he reaches with the end of the longer rope still in the boat. He then begins to draw the end of the net towards the shore by means of the rope so that any fish that has met the net would be driven on shore did it not take refuge in the bag. When he reaches the end of the net he calls to his companion "gale" (probably a corruption of the Welsh word "gael" —to get), meaning that he has got it. His companion then comes towards him along the bank dragging his end of the net with him, the net is hauled in till the bag or purse is reached and the fish secured. Trammels are not

allowed in this narrow part of the river as being too destructive. Formerly not only were these nets allowed but also nets with meshes small enough to catch Eels and Smelts or Sparlings* as they are locally termed (*Osmerus eperlanus*), but the latter fish having become almost extinct in the Dee, and the fine meshed nets being very destructive to young salmon, they were prohibited by a bye-law of the Dee Fishery Conservators.

Below the point mentioned above both draft and trammel nets may be and are used. The trammel is a straight net which, being lightly weighted along the lower side and having corks on the upper, hangs like a wall of network in the water. This "wall" consists of a net of $2\frac{1}{4}$ in. mesh between two others of 11 in. mesh. The mode of using it is to attach a buoy to one end of the top rope, the other end being held in the boat by one man while the other boatman rows across the channel, allowing the net to "pay out." When it is all out the net is stretched across the channel and the oarsman has to keep the boat in such a position that the net shall drift down the stream stretched to its full extent and at right angles to it. When a salmon swimming up the river strikes the net he forces the $2\frac{1}{4}$ in. net through the 11 in. mesh on the opposite side to that which he strikes and thus forms a bag in which he becames hopelessly entangled. The net is drawn into the boat at intervals, and any salmon caught taken out. This net is generally considered as more useful than the draught net and, being far less laborious, is a great favourite. In a narrow channel it is very deadly.

* "Smelt," the word in use in the S. and E. of England, is the Danish word for this fish. "Sparling" is probably a corruption of the French "Eperlan," and may have been introduced by the Normans. The Welsh name is "Brwyniad" from "brwyn," a rush, alluding to the rush-like smell of the fish when freshly caught.

Both kinds of nets however are in use down the channel of the Dee from the point below Connah's Quay above mentioned down to Dawpool Deeps and possibly further.

Considerable friction exists between the different classes of fishermen on the Dee, viz.

1. The riparian owners on the river from Bala Lake to Overton. These allege that there are now so many nets at work on the lower river that very few salmon can succeed in reaching the upper waters until so late in the Autumn that rod-fishing, which closes November 1st (net fishing ceases on September 1st), is almost over.

2. The coracle fishers of Overton and the draught-netters of Chester. These say that the Connah's Quay men with their trammels get nearly all the fish before they get into the narrow part of the river· Both the Chester and Connah's Quay men complain of not being allowed to use trammels for flat-fish during the close-time for salmon.

As regards the riparian owners and rod fishermen of the upper Dee, it must be borne in mind that it is of the most vital importance to all classes of fishermen that the spawning salmon should be protected on the shallows to which they resort and on which they would undoubtedly be taken by poachers were they not watched by the keepers of the gentlemen who preserve the fishing; and it seems hard to grudge these their sport (never very good in the Dee) which they expect in return. And it is clearly as much to the interest of the net fishermen of the lower Dee as to the sportsmen of the upper that a sufficient number of fish should reach the spawning beds, as on this depends the number of salmon that will re-ascend the river in future years. In order to enable more fish to run up and at the same time to check the killing of "foul"

fish descending the river after spawning (and it is said that the fish taken in February were almost exclusively these), the close time has recently been extended to April 1st instead of February 1st as formerly. And to meet the complaints of the Chester fishermen the cost of the license for a trammel net has been raised to £15, that for draught nets remaining at £5, and the coracle nets at £2 10s. as before.

The question of the use of trammels for "Flukes," i.e., Flounders, Plaice, and Dabs, (*Pleuronectes flesus*, *P. platessa*, and *P. limanda*) during close time is a difficult one. It is questionable whether it could be carried on profitably were it not for the occasional illicit captures of salmon said to be made and for which, it is asserted, purchasers can always be found. On the other hand the fishermen say that salmon are not taken, owing to the mode in which the nets are set for Flukes. Possibly the case might be met by absolutely prohibiting the use of nets of any kind during the months of September and October, when the greatest run of Salmon generally takes place, and allowing free netting below Connah's Quay after that—the taking of Salmon of course not being permitted during close time.

The next river (following the coast to the westward) is the Foryd as the united streams of the Clwyd and Elwy, from their junction between St. Asaph and Rhuddlan to the sea at Rhyl are called. Draft nets from 30 to 90 yds. long, with the legal mesh, are used from Rhuddlan Bridge to the sea, and rod-fishing only in the rivers above, which are small. The close time is from September 15th to May 15th for nets, and from November 15th to May 15th for rods. It is a very late river, the principal runs of Salmon and Sewin up the river taking place in September, October, and November. The cost of licences in 1891

were £3 10s. for a net and £1 for a rod. Nets with a mesh less than 2 in. from knot to knot are said not to be allowed in the river.

The third and last river in the district under consideration is the Conway. This is a more important stream than the last, and large numbers of Salmon and Sewin run up it annually. Mr. C. T. Allard, Hon. Sec. to the Conway Conservancy Board, informs me that the principal runs are, of Salmon towards the middle of June, and of Sewin in April and the beginning of May. The late Mr. John Blackwall, F.L.S., who lived for many years at Llanrwst, says, in an interesting paper "On the growth of Salmon and Sewin" (Researches in Zoology, 2nd edition, 1877, p. 184), that "Salmon in high condition, weighing 3 lbs. and upward, ascend the Conway in considerable numbers early in June if the state of the water be favourable"; and that "great numbers of young Salmon, weighing from half a pound to a pound, come up the same river in August." I do not think the large spawning fish run up till somewhat late in Autumn.

This river is fished with nets, chiefly draft with the legal mesh, from Trefriw to Conway, and with rods above Trefriw. Only one draft or trammel net appears to have been licensed in 1891, and one coracle net in the Tanyrallt fishery near Bettws-y-Coed. There are two "Weirs" or fixed enclosures for taking Salmon in this fishery district—one at Colwyn Bay, about five miles E. of the mouth of the Conway; and one at Caerhun on the river. There is also licensed a "Fixed Engine," consisting of a basket 7 ft. long, at Tanyrallt. The annual close time is from September 15th for nets, and from November 15th for rods, to April 30th. The cost of a license for a draft or hang net (trammel) is £3 per annum, and for a rod £1 per annum.

In addition to the above, small meshed draft nets are used for Smelts or Sparling (which are taken in considerable numbers and comparatively large size between Llanrwst and Conway) during March and April; and draft nets of larger mesh at the mouth of the river for Grey Mullet (*Mugil capito*, Cuvier). This fish is now becoming scarce.

There are one or two smaller streams along the coast, as the Dulas between Abergele and Colwyn Bay, and the Aber a little east of Bangor, but I am not aware that Salmon run up them though a few Sewin do.

Sea Fisheries.

On this subject there is little to be said. There is no doubt that the Welsh are not in their proper element on the sea, and though there are many small coasting vessels manned by Welsh sailors, yet, as a rule, they are very cautious in trusting themselves far from a port. As a class fishermen may be said not to exist on the Welsh side between Connah's Quay on the Dee and the Menai Straits. Yet Mostyn, Rhyl, and Conway have at least as good harbourage as Hoylake where there is a considerable fleet of fine fishing boats and a body of fishermen second to none in skill and hardihood. There is (or was) one small fishing boat at Bagillt engaged in getting mussels from Dawpool, cockles from the banks in the Dee and occasionally trawling at the mouth of the river. At Rhyl four boats are engaged occasionally during the winter in setting long lines for Cod, but they do not go more than one and a half mile from the shore. Lines are also set at low water of spring tides, both here and along the coast, but rather as an amusement by working men than as a means of gaining a livelihood. Codling and Conger Eels (where there are rocks) are the principal fish taken in this way.

At Colwyn Bay one man sets long lines for Cod during the winter months, going out as far as the Constable Bank (nearly 5 miles) at times, and with fair success. Stake nets are also set all along this part of the coast for Herrings in October, November and December, and considerable numbers are taken. In the "weir" too at Rhos above mentioned, besides Salmon, large quantities of Herrings are taken. In July, 1891, 9000 were said to have been taken in one tide. Many other kinds of fish are also taken there, such as Mackarel, Anchovies, Gar-fish (*Belone vulgaris*), and Bass (*Labrax lupus*). These last, though constantly present in the weir during high water, yet are comparatively seldom taken in it, having the sense to swim out before the water has fallen too low. They are however often taken within the enclosure at high water with rod and line, that being indeed the favourite place for fishing for them. Whitebait, i.e., young herrings, are also present in enormous quantities during the summer. Many other kinds of fish are taken occasionally in the weir, but the above are the most abundant.

At Conway, in spite of an excellent harbour, there has not been a sea-going fishing boat owned by native fishermen since 1855. The so-called fishermen confine themselves to netting for Grey Mullet, and fishing in the river with hand lines for Codling and Bass, but their principal livelihood is derived from raking up mussels in the channel below the town and hiring their boats to visitors for fishing or pleasure parties. Yet a boat comes every winter from Lancashire to fish for cod with long lines, lying in Conway for that purpose.

In the Menai Straits again I have heard of no fishing except by hand-lines, nor indeed anywhere along the coast of Anglesea, though at Bull Bay and Valley, and possibly elsewhere, there are considerable Lobster fisher-

ies. There are certainly both Crabs and Lobsters in the neighbourhood both of the Great and Little Orme but no attempt is made to get them, though there is a market for them close at hand in the various watering places along the coast. Holdsworth (Deep Sea Fishing and Fishing Boats, 1874, p. 183) says "The Welsh Fisheries, so far as they depend on the native population, are quite unimportant except with respect to oysters. There are a few large trawlers at Carnarvon and Tenby; but the Tenby ground and, as we have already mentioned, Carnarvon and Cardigan Bays are principally fished by trawlers from English stations. Line fishing and a little drifting are carried on along the coast, but the boats in use are generally small, and the supply of fish is barely sufficient for local demands. The lazy methods of fishing with weirs and set nets for herrings and chance fish are adopted in some places with occasional success; but apart from what may be a question as to the abundance or scarcity of fish on the Welsh coast generally, the great development of the mining and quarrying industries in the principality will always be likely to interfere with much local attention being given to a systematic prosecution of the Sea Fisheries with their attendant uncertainties." Mr. Holdsworth, gives a list of the fishing boats on the Welsh coast, from which it appears that in 1872, there were 14 first class, 115 second class, and 36 third class boats in Carnarvon, but there does not appear to have been a single boat—indeed he does not mention a port between Carnarvon and Aberystwith—in Merionethshire. Assuming this to be the case now (and I suspect there is less rather than more fishing along the Welsh coast now than in 1872), it seems hard that Merionethshire should be called upon, as it has been, to pay a considerable sum towards the expenses of the Welsh Fisheries Board. It

is not stating the case too strongly to say that this county is not interested in the improvement of our Fisheries one-tenth as much as London and such populous inland Counties as Staffordshire and Warwickshire.

There is no escaping the conclusion that the supply of fish is a matter not of local, but of Imperial importance, and that consequently the expenses of protecting and improving it should be met entirely out of the Imperial taxes. This again entails, and ought to entail, Imperial control over the means employed in such protection, which would put an end to the local jealousy or indifference which so often interferes with the attempts made to improve the Fisheries. To take Liverpool Bay as an example, its south coast is all Welsh, and we have seen, there are practically no fishermen on that part of it. Is it fair then to ask Flintshire and Denbighshire to contribute towards the expenses of a Fishery Board for Lancashire and Cheshire by which the former Counties will only benefit the same extent as the inland Counties? Again the Cheshire County Council have refused to allow the important breeding ground of the estuary of the Dee, to be placed under the control of the Lancashire Fishery Board, while they themselves have not as yet taken any steps to mitigate the immense destruction of immature fish probably caused by the Parkgate shrimp trawlers. I am however informed by Mr. R. Potts, Clerk to the Cheshire County Council, that the Dee Fishery Board have now applied to the County Council for a grant to enable them to protect the Sea Fisheries in the Estuary.

There is a prevalent opinion, in which I myself share, that the Sea Fisheries of the area under consideration have become less productive of late years. Whether this is caused by over-fishing, destruction of immature fish by trawls (especially shrimp trawls), or by sea birds, which

have probably increased in numbers since the passing of the Wild Birds Protection Act, or by all these combined, remains yet to be proved. There can be no question that Cormorants, which breed on the Ormes Heads and are now very numerous, destroy immense numbers of young fish both on the sea and in rivers. I have even seen one fishing on the Dee near Corwen.

Shrimp and Shank Fisheries.

These are of considerable importance to the fishermen of Parkgate who trawl for them both in the Dee and along the coast of Flintshire, sometimes perhaps going beyond the Voryd. As far as I know there are no Welsh boats in the district under consideration which trawl for shrimps, and not many perons who fish with hand-nets. The Common Shrimp (*Crangon vulgaris*) is generally taken in water so shallow as barely to float the boat and on sandy ground. Only the trawl is used, by which I mean a beam trawl similar in all respects, except size of mesh, to the fish trawl.

The Shank (*Pandalus annulicornis*) is taken in the same manner, but on stony ground and generally in rather deeper water. They used to be very abundant on the bar of the Dee off Prestatyn. I have seen them swarming among the stones in Colwyn Bay, at low water of spring tides. A few true Prawns (*Palæmon serratus*) are generally taken with them.

Mussels, Cockles, &c.

Mussels (*Mytilus edulis*).

There is an important Mussel bed in Dawpool Deeps which is fished by the Parkgate men with long handled rakes to which a net is attached. There was a smaller bed at the mouth of the Voryd, but I was informed this

year that it had been almost entirely destroyed by the gravel dredgers who have scooped up both gravel and mussels and shipped them to the Manchester Ship Canal, for making concrete. At Conway there is a very important bed forming the chief resource of the fishermen there who both sell and use them for bait in Codling fishing with hand lines. This bed was becoming much exhausted, but the Carnarvonshire Fishery Board have now imposed a close time of three months which, it is hoped, may restore it. It is a pity that the fishermen are not compelled to sort the Mussels at the beds, throwing the small ones in again there, instead of bringing them up to the town and picking them over on the shore. As however the sorting is done close by the river and the small ones thrown in, they probably get carried down to the bed again by the current.

It would seem that the Mussel only grows to a large size at the mouth of a river. I have found at times in dredging in Rhos Bay small Mussels in such masses as to be a nuisance (from a Naturalist's point of view) but none of anything like a marketable size.

So far, I believe, nothing has been done to protect the Mussel fisheries either in the Dee or Foryd.

Freshwater Mussels.

The Rev. Robert Williams in his history of Aberconwy (Conway), 1835, speaks of the *Unio margaritifer* as being fished for above Trefriw for the pearls they sometimes contain, though the search for them did not afford constant employment. On the other hand, he states that the edible Mussel (*Mytilus edulis*) was collected and destroyed in immense quantities for the sake of the few pearls found. I am not aware that either species is now collected for that purpose.

Cockles (*Cardium edule*).

In the Estuary of the Dee from Bagillt downwards on the Welsh side this Mollusc forms an important item among the industries carried on by women and children. This is especially the case at Bagillt and Greenfield. It is found on sandy banks which are uncovered at low water of moderate tides. They are also sought for at Rhyl and probably Abergele but no further, the sand banks not being sufficiently entensive to the westward. They are usually dug out with an old knife. No regulations have as yet been made for their protection.

Clams (*Mya arenaria.*).

These are found in considerable abundance in the somewhat muddy sand banks opposite Bagillt Wharf. They are sometimes, though rarely now, collected for food, but are little esteemed. The shells of *Mya truncata* are commonly washed up at Colwyn Bay, but it is not sought for. An attempt was made in 1882 to acclimatize the American Clam (*Venus mercenaria*) supplied to me by our late President, Mr. T. J. Moore, for that purpose. Some were put down in the Dee opposite Bagillt Wharf, some in a tidal pool at the same place, used for flushing out the wharf, some in the Voryd by the railway bridge, and some on the shore at Colwyn Bay. I have never seen live specimens nor dead shells at any of these places. The tidal pool was cleaned out in 1887 or 8, and I offered a reward for any Clam (American) that could be found, but not even a single valve was discovered, though the whole of the mud to the depth of 2 feet was dug out. I may refer here to the notice on *V. mercenaria* by Mr. Moore (L.M.B.C. Report I, p. 368.)

Oysters (*Ostrea edulis*).

I am not aware that there is any natural bed of this valuable mollusc in the district of sufficient extent to be

worth dredging. There is a bed in Colwyn Bay, but it is not fished. There were formerly considerable artificial beds at Beaumaris where American and other oysters were laid down, but I believe these are now abandoned.

I have to thank Mr. Reginald Potts of Chester, Major Leadbetter, Hon. Sec. River Dee Salmon Fishery Board, Mr. C. T. Allard, Clerk to the Conway Salmon Conservancy Board, and Mr. C. Grimsley of St. Asaph for valuable information on the fisheries of their respective rivers.

To be inserted after p. 58 of A. O. Walker's Revision of Podophthalmata in "Fauna of Liverpool Bay," Vol. III, 1892.]

ADDENDA TO REVISION OF PODOPHTHALMATA.

By A. O. WALKER, F.L.S.

The following species were either accidentally omitted from the "Revision," or were found this Summer shortly after the volume had been issued.

Pinnotheres veterum, Bosc.

One male and two females from the branchial sacs of small specimens of *Ascidia mentula*, measuring about 1½ inches in greatest length; dredged off Clay Head, Isle of Man, 12 fath., Sept. 24th, 1892.

Prof. Herdman informs me that the branchial sac was almost completely filled transversely by the *Pinnotheres* which could not possibly have got either in or out of the Ascidian at anything like their present size.

Pirimela denticulata, Mont.

Dredged by Mr. A. Chopin, from 15 fath., off Spanish Head, Isle of Man, Sept., 1892.

Inachus dorynchus, Leach.

Four specimens from Puffin Island, Beacon Rocks, and West Spit; low water, spring tides, March, 1888.

Stenorhynchus longirostris, Fabr.

West of Calf of Man, 20 fath. "Hyæna," May 20th, 1888.

Ebalia cranchii, Leach.

One male; Laxey Bay, Isle of Man, 12 to 20 fath. on "Melobesia" ground, Sept. 24th, 1892.

Spiropagurus hyndmanni, Thompson.

Isle of Man, "Hyæna," May 19th to 21st, 1888 (Rep. II, p. 69); Porthwen Bay, Anglesea, 20 fath., June 8th, 1889 (Rep. III, p. 243).

Nephrops norvegicus, Linn. (Rep. I, p. 223).

This species, which was doubtfully recorded in Report I, is now known to be abundant off the South end of the Isle of Man.

The OCCASIONAL PHENOMENAL ABUNDANCE of CERTAIN FORMS of INSECT LIFE.

By W. E. SHARP.

[Read 11th November, 1892.]

THE subject of the present paper is one which appears to me to merit the attention of all biologists. The phenomenon of the greater or less abundance of individuals of any particular species at different times extends throughout the whole of animal life and is indeed one of the most obvious facts of nature. As might have been expected this waxing and waning of vitality is most obvious and most emphatic in those groups whose vital economy is most delicately adjusted to their environment. Of course also the shorter the individual life and the greater the capability of increase, so much the greater is the possibility and indeed the actuality of extreme irregularity of survivals. Thus the phenomena of which I am treating is found most obtrusively noticeable among the Insects, both because that group comes more immediately and constantly under notice, and because while the capability of racial increase is very large, the span of individual life is usually very short rarely indeed more than annual, or at best biennial. I think I might also add that the fact of the extreme disparity between the various states of insect embryonic development renders that class more liable to fluctuations of survivals, because the relations between the individual life and the environment are necessarily so much the more complex and variable.

That this phenomenon of sudden and unexplained abundance is not unknown among even so highly devel-

oped and apparently stably conditioned a group as the mammals, the farmers of Dumfries and Galloway have lately had reason to their cost to know. But it is to certain extraordinary instances of its occurrence among the Insecta that I wish on this occasion to refer. Now examples of what I allude to, of the sudden profusion of some particular species are so common that I need scarcely recapitulate them. Cases of the kind are met with to whatever order of insects attention may be directed. But as the attention of most entomologists is, and for a long time past has been directed more especially to the Lepidoptera, and as amongst the Lepidoptera some of the most remarkable cases are to be found, I will for the present restrict consideration to that order.

The common white cabbage butterfly *Pieris rapæ*, may be confidently expected to make its appearance each year with the first warm sunshine of April. At first it is the harbinger of spring, later however this insect outstays its welcome and degenerates into a garden pest. However cold or wet the season, this species never fails and is nearly always and in all places equally abundant. But the garden white has a not very far distant relative *Colias edusa*. Here in the north of England this is one of the rarest of British Diurni, at any rate had been so till the year 1877 and then, suddenly, apparently without cause, in that late and wet summer came this butterfly's epiphany. On that occasion *C. edusa* might have been seen in every clover field and by every grassy road side throughout this district.

This was 15 years ago and since that summer with the exception of some single captures reported in September 1888, not one has been so much as seen. And yet contrasting such an erratic insect as this with our unfailing garden whites, no casual investigation can discover in

their physiology, habits as imagines, or food as larvæ, any good reason why one should appear with the regularity of the East wind and the other but twice or thrice in a lifetime. I mention this case, because it was perhaps so to speak one of the most dramatic on record, but the entomologist knows that hardly a year passes without some such exceptional manifestation, sometimes a lady-bird, sometimes a hawk moth. No doubt it will be remembered how some years ago on the hills near Clitheroe, appeared armies of the larvæ of the Antler Moth *Charœas graminis*, how like an Egyptian plague they suddenly became manifest devastating the grasslands, and how they disappeared with the celerity of the frogs and of the lice. Again in 1879, one of the coldest and wetest years of this century, a butterfly *Vanessa cardui*, and a day flying moth *Plusia gamma* literally swarmed not only over the whole of the Continent but also all over Great Britain from Wick to Penzance. And even this summer we have just passed through has been marked in red, by reason of the unusual numbers of a moth as beautiful as it is generally rare, I mean *Deiopeia pulchella*.

The tale of similar instances might be indefinitely prolonged, but instead of reiterating cases which are but examples of the same phenomena, I want to focus attention more especially on one particular species of insect which perhaps more than any other has attracted the notice of entomologists by reason of the remarkable irregularity of its appearances and the profundity of its disappearances. The species I refer to is the hawk moth *Deilephila galii*, so called because its larva feeds on the *Galium* or yellow bedstraw. This moth is distributed generally but sparingly over Europe, more frequently in the South, and is found also in Asia and North America.

Now the butterfly *Colias edusa* of which I spoke,

although here phenomenal in its visits, can be taken almost every year not uncommonly in the South of England, but the remarkable hawk moth, the subject of this paper, is in Great Britain *everywhere* very rare except on occasions, in which no particular periodicity is visible, and then it is found in its own haunts in great profusion, from Perth to Deal, and from the Hill of Howth to Cromer; principally indeed on the coasts because its larvæ feed on the bedstraw, that herb which gives that peculiar aromatic fragrance to the sand dunes, which line in so many places our shores.

Its last appearance was in 1888 and most of our local entomologists made the acquaintance of its larvæ during that year for the first time, for during eighteen years not a trace of it had been seen, although the sandhills where alone locally it has ever appeared at all is a district perhaps better worked by entomologists than any other in the two counties. The unexpected apparition of this insect or rather of its larvæ, for one of the points to notice is that the larvæ always seem more in evidence than the imagines, during so inclement a season as 1888, provoked as might have been expected considerable comment among entomologists. The phenomenon was indeed only one out of many kindred instances constantly occurring and universally recognized, but it seemed more emphasized perhaps in this case because the moth is a large species, not easily overlooked either as larva or imago, a great desideratum among collectors, and because of its apparent utter extinction for the preceding eighteen years. The affair then as I say created no small stir in entomological circles, and many papers appeared in the organs of the cult, elaborating various theories to explain this mysterious recrudescence of *Deilephila galii* in the summer of 1888. My own attention among other entomologists was

arrested by so singular a spectacle, and because I failed to find in the various theories promulgated that *vera causa* which I felt to be wanting I was led to investigate the matter a little more closely and from another point of view, and it is the result or absence of result of this enquiry to which I am now directing attention.

The problem to be attacked stands somewhat thus. A certain Lepidopteron *Deilephila galii*, which discovers the antiquity of its pedigree and the perfection of its developmental adjustment in a range which extends almost all over the northern temperate zone, here in Great Britain is normally one of the rarest of our insects, but as far back as authentic entomological records go has appeared during the last sixty years on four occasions in phenomenal abundance. These years were 1834, 1859, 1870, and 1888. So scarce is this insect that in all the years amounting to fifty-four which made up the intervals been these *anni mirabiles*, probably not a score of specimens in any stage have been captured. Yet in those particular summers *Deilephila galii* turns up in *every* place in which it has ever appeared. That is to say almost wherever the *Galium* grows, there in a "Galii" year is *D. galii* to be found, and such spots are virtually wherever round these islands there are sandhills to grow *Galium* and entomologists to record the moths or the larvæ.

Now there must be some reason for this, science knows not the idea which men call chance. Some sufficing *cause* must have produced these abundant crops of *Deilephila galii* in those particular years, and it is to discover this cause that my efforts are directed.

I cannot find that previous to 1888 any attempt at an explanation had been offered, but that year, being the occasion of the most abundant manifestation yet recorded saw several theories broached. Most of these were by

entomologists whose observations were restricted to the Southern and South Eastern coasts and perhaps naturally they found in migration from the Continent an explanation for the sudden appearance of the species there. The moths they say came over from an indefinite somewhere during the June and July of that year and the numbers of larvæ found during the autumn were simply the offspring of those insects, doomed to swift extirpation in a climate fatal to their development. To such a view as this most of our leading London Lepidopterists seem now to adhere. That veteran entomologist for instance Mr. C. W. Dale, F.E.S., of Glanvilles Wotton, in an exhaustive account of the British Sphingidæ now being issued in serial form, after mentioning the various localities where on its last appearance *Deilephila galii* was recorded, thus sums up the case. "This I think goes to prove (referring to the fact that the insects were specially numerous on the South East Coast) that the migration came not from France but from Belgium and Holland, the route followed by *Antiopa* (a butterfly assumed to be a migrant). Those finding congenial quarters on the coast of Kent stayed there, while those which arrived in Yorkshire mostly went on to the coasts of Lancashire and Cheshire and perished soon after laying their eggs." And again finally thus—"The only years in which it has been common are 1834, 1859, 1870, and 1888, and owing to our inclement autumns it seems unable to propagate its species in the British Islands for any length of time."

The inference clearly is that *galii* is not strictly speaking a British moth at all and that those individuals who are ever seen here are either immigrants from the Continent or the immediate descendants of immigrants.

Dr. Corbett of Doncaster, says "When the case of such an insect as *galii* is considered, I think that most prob-

ably we shall find that it is—so far as Britain is concerned—a purely imported species, and that in all probability our climate is not suited for its permanent residence with us."

Then another well known London Entomologist Mr. W. Tugwell, says, "To migration I fully believe we in England are indebted for many other species (besides *galii* he means) but that the climate does not suit *Deilephila galii* and it in consequence soon becomes weak and fails to be fully established."

This gentlemen also backs his opinions by the only piece of direct evidence, such as it is, that I can discover to have been adduced by the migrationists namely—that specimens of the imagines *bred* by him from larvæ he had taken at Deal, were considerably smaller insects than imagines taken at large on the wing; the presumption being that the latter were of continental origin and therefore larger than the British born insects. I doubt however whether there was a sufficient number of the imagines captured in Britain at all to make the comparison of any value. Passing by this however, besides the citations just given—we have such well known authorites as Mr. Tutt of London, and Mr. Robson of Hartlepool, declaring their adherence to the migration explanation of the of *Deilephila galii* in these years.

Thus we find nearly all the entomologists who have expressed any opinion on the matter at all going solid for immigration and it would be one feels, a somewhat presumptuous and even reckless thing to question an opinion so united and so authoritative did one not harbour a faint suspicion that this singular unanimity might be due less to the conviction of the strength of the evidence which supports their theory, than to the natural dislike we all feel to suspended conclusions, or the admission of complete ignorance as to the true solution of so notorious

a problem in Entomology. And now I will examine this theory a little more closely. It is that vast numbers of the imagines—the moths—of *Deilephila galii* cross the sea from somewhere and replenish these islands during the "Galii" years. Now it is at once obvious that for a scientific explanation this theory is not nearly definite enough. We want to know not only *whence* but also *why* they come. And be it noted, the only evidence that they come at all, is in the fact that they appear in England suddenly, without visible progenitors.

But when we come to ask our theorists, whence are these swarms derived? they decline to commit themselves to any definite reply. It might either be from the land of the midnight sun or from beyond Atlas for all we are told to the contrary. Mr. Tugwell and Mr. Dale indeed conjecture from Holland and Belgium, but we have no evidence, not a shred, that on those particular years, this moth was in unusual abundance in the Low Countries. It is a pure assumption that the migration, if migration there were, originated on those coasts, based on no better reason than that these form the nearest land to the littoral of Kent and Essex where the larvæ were abundant: but they were also no less abundant in the Wallasey sandhills and were not discovered at all on the coasts of Hampshire and Dorset, which are certainly much nearer the Belgian shore than is Crosby or Wallasey.

And if it is thus difficult to answer the question of origin, it is impossible to answer the question of cause. We are at once involved in the whole theory of migration. Now it here occurred to me that this term migration was used in much too vague a way. There are two distinct and indeed incompatible ideas here covered by the same term. One of these, not both or either, must be the migration, which compels *galii* from the Continent, and

although our friends have not as far as I have seen, in any place explicitely defined what they mean by migration as applied to this insect, yet it is necessary for us to be clear on the point if we attempt to show how in our view no kind of migration at all will fit the case.

You may if you like call that merely indefinite progression such as we see in the Locust swarms, in the march of the Termites, in the discursive flight of such a butterfly as *Vanessa cardui*, migration; but more justly should that term be applied to the recurrent flight of the swallow and the fieldfare. Migration properly so called seems defineable as a recurrent change of habitat, definite as regards direction, periodic as regards time, induced by instinct and originating in some consequential benefit to the race.

Now I think I am safe in asserting that such a migratory instinct or practice as this is quite unknown among insects. In the first place among the vertebrates the compelling factor is the need for similar or at any rate sufficient food during differing seasons, as well as the necessity involved in the correlation of certain organisms to certain temperatures, but the general brevity of all perfected insect life, and the fact that such forms as do survive one summer invariably pass the winter in a more or less dormant state, forbid us to believe that among them any such instinct could have similarly arisen; and in the second place, the entirely dissimilar condition under which the various stages of insect development are passed make it difficult to imagine how a habit such as definite and regular migration could have arisen, which *ex hypothesi* must have been a benefit to the insect during the *whole* of its varied existence, as an environment beneficial during one phase might be quite the reverse during another. The migrationists I admit although not very

explicit in the exact meaning they attach to the word, probably would not contend for a migration so instinctive as this, but in order to exhaust the question we must analyse all the senses in which the term can be employed. They probably, although not expressly, mean one of two things; either a quasi-instinctive tendency to dispersal, a blind impulse comparable to that which drives the Norwegian lemming ever westward into the sea, or else simply a quite involuntary movement caused by the only possible agency, namely the wind. Now touching the first case, I am far from denying that there exists among many insects this quasi-instinctive tendency to wander. I do not however consider the example of locusts and ants at all to the point, because what impels these insects to their notorious flights and marches is simply the necessity for fresh food, the whole land is a wilderness behind them, and the question ever before their legions is either starvation or a move onward; but no sane entomologist would I think for a moment assert that any number of moths like *Deilephila galii* could so exhaust all the nectar of all the flowers on say the Belgian coast that they were compelled to seek fresh woods and pastures new across the German ocean.

More relevant is such an insect as the butterfly *Vanessa cardui* the well known but ill-named "painted lady," rather should this be called the Ulysses of the butterflies, so deeply does the spirit of roaming seem to have infected its very nature. There is no habitable land I believe from New Zealand to the Arctic circle of which *cardui* is not a denizen. Usually fairly common in Europe it sometimes, as in 1879, appears in innumerable multitudes and over-runs a continent exhibiting in this character of occasional abundance a curious similarity to the moth under discussion. In this year, 1879, it appeared during

early summer in Italy and all the South of Europe and like an inverted Gothic invasion, steadily ceaslessly the northward march, or rather flight, went on all through that year till the last of their armies died out in late autumn discolouring the Scandinavian snows.

Now that remarkable flight is an ascertained *fact*, and although I do not maintain that those same identical insects which broke their pupal envelope on the plains of Lombardy or on the African shore ever reached the Baltic coasts, or indeed did much more than flutter helplessly to earth a few hundred miles from their native thistle, yet the decimated regiments were filled up by ever fresh recruits and the general impression given was a northward progress of incalculable host of *Vanessa cardui*.

Now the reason of the emergence in that particularly inclement year of all these butterflies, the reason of their northward flight, or any flight at all, I am not concerned now to explain. My point is rather, that it is most unscientific, most unjustifiable to assume that the causes which made the Sphinx moth *Deilephila galii* plentiful in certain spots round the English coast in 1870 and 1888 must necessarily or even probably be the same as, or similar to those which induced these prodigious flights of *Vanessa cardui* all over Europe in 1879. We must judge each case on its own merits. Consider then the difference; *cardui* is a strong winged day flying butterfly of particularly robust constitution whose larvæ feed on thistles principally, a herb common wherever the foot of man has trodden.

Deilephila galii is a delicate hawk moth only flying during the dusk whose larvæ feed so far as is known only on the bedstraw and the willow herb, plants narrowly restricted in area of growth and far from common anywhere. The flights of *cardui* are visible, notorious; they settle on

ships far out at sea; in that great year of their abundance, the English coast was strewn for miles with their sea borne corpses, the wrecks of their scattered armies. They were simply ubiquitous. But of *galii* there exists no record of a single one ever having been taken anywhere alive or dead except somewhere near sandy tracts where the *Galium* grows, or bogs and mosses where the willow herb abounds. The species does not even frequent gardens like the other hawk moths; my friend Mr. Robson of Hartlepool, admits that although specimens of most strong flying Lepidoptera have been brought to him by mariners of that port caught far from land or temporarily settled on ships never once not even in that year when the channel to support his own views should have been alive with *galii* has a specimen of this moth been brought to him.

So far as regards direct evidence—but now let us consider the question for a moment theoretically. It is necessary to measure the effect of such a tendency by benefit derivable by offspring. Now *cardui* must indeed fly far and wide to be unable to find a thistle leaf in which to deposit her ova and sustain her infant family of larvæ, whatever may have been the cause which developed in her that tendency to wander, such a tendency has evidently been in no way mitigated by any consequential injury to the larvæ. But consider now *galii* what are the chances, if *she* leaves those beds of *Galium* or Willow herb which sustained her tender larval infancy, of her meeting with others on which to deposit ova, compared with the chance of her finding herself in a land where is neither bedstraw nor anything else serviceable for her purpose? Here we see no possible benefit derivative, quite the reverse.

Still more easily demonstrable is the great improbability of any such instinct having become implanted in the species from the very fact which the imigrationists them-

selves not only admit but rest half their theory on namely that these venturesome individuals, who according to them *do* cross the narrow seas, leave offspring only to be exterminated by the rigor of a climate unsuited to their constitution, that is to say that the emigrants leave no descendants, those who stay behind do—and yet the tendency to emigrate becomes confirmed and perpetuated in the race—and this is survival of the fittest!

Now so constant, so inflexible seems to be the application of this great principle, that only the fittest survive, that this one consideration does for me effectually dispose of the migration theory of the erratic abundance of *Deilephia galii.* That is, that allowing such a migratory instinct, or tendency to dispersal—call it what you like—ever to have arisen, either such a tendency would have become eliminated, or the whole species would have become extinct, if its exercise led as *ex hypothesi* we must believe that it would lead to the utter extermination of these individuals who practise it. That conclusion seems to me unavoidable, and I would so leave that part of the subject, holding that neither by fact nor by theory can the phenomenal abundance of this moth on certain years be explained as due to any form of voluntary migration.

So far then I have treated of what might be called voluntary movements, but there are also involuntary journeys, and our theorists never seem quite able to make up their minds as to which sort they attribute the presence here in its years of this moth. Involuntary movements are certainly much the simpler, there is but one possible agent, the wind, and the wind to be a possible agent must blow at the required time from the point whence the insects are supposed to be driven to the point where they are subsequently discovered, and of course only imagines can be the subjects of such carriage. Now take

1888, the last, the best studied, the most notorious year of their abundance. The imago is out perhaps at the end of May on the continent and must have been blown across during June and July to be present here at the time when the few captures here were made. Then there ought to have been during that time winds continuous or at any rate frequent from the south east or east. But as a matter of fact the prevalent winds during those two special months were west, north west, and south west and only on about ten isolated days did the wind blow from the requisite quarter. In fact this particular summer which brought the moths had less east and south east winds than almost any of the preceding eighteen years which brought no moths. There are other difficulties besides this to surmount, thus the wind cannot be supposed to be discriminative in its effect. Allow a cloud of moths wind driven from the Dutch coast, and carried bodily across the German Ocean, their disposition on arrival must be purely mechanical, we should have individual moths rather battered and worn, distributed indiscriminately all over England more in the eastern coast and thining out as one proceeded westward. What are the facts? nothing like this. We have a great many moths fresh as though just emerged from the pupæ segregated in particular small localities, more actually occurring in a spot of a few acres almost as far west as one could get, than in all the country between Thames and Tweed. Such considerations seem to me to effectually dispose of the wind blown theory. If we had only the case of *Deilephila galii* in Kent and Essex I should admit the hypothesis to be not utterly untenable, but it is its presence here in Cheshire and in Ireland which it is impossible to reconcile with a distribution caused solely by the agency of wind.

But another and still more startling explanation has

been suggested to account for these years of abundance. That is the retarded development or "laid over" theory, as it is called. This assumed that the development of the pupæ of *galii* sometimes, in fact generally, owing to some mysterious influences is retarded for years. There is no invocation of continental swarms here. *D. galii* is always with us but generally in the pupal state, then once in a long series of years, owing to some influence equally occult, pupal maturity arrives and with one accord the long lost moths emerge into the light of day.

Now this theory might be debateable were there any parallel case known in the whole insect world; but besides the fact of the supposition of pupæ lying buried for 18 years being utterly inadmissible and unsupported by one scintilla of evidence, the idea only lands us in a still denser jungle of inexplicabilities. It is difficult enough to rationally explain why *galii* should turn up at an 18 years interval, but the introduction of mysterious influences which retard the pupæ, and defer or compel the emergence in certain years of the imago does not tend to make things any clearer. It is true that the monstrous assumption has been ventured upon that the sufficing cause is the very structure of those hills of sand among which the insect in most places lives. The idea is that the sandhills move, cover up the pupæ and preserve them until such times as some further or retrograde movement of the sand uncovers those pupæ and liberates the imprisoned moths. Now that these masses do move owing to peculiar wind action is certain, no less certain is it that did a thousand tons of sand or so move bodily and heap itself up over any congregation of buried pupæ, such an obstacle would defer the emergence of the imagines; but not for eighteen years, the deferment would be for all time. No resurrection morning would ever come to those pupæ. I indeed

would not care to deny that great, prolonged, and equable cold, might even for very considerable periods retard the emergence of imagines from pupæ, but not destroy pupal vitality, such retardation would be caused by a complete cessation of organic development while the cold lasted, and the cold would probably require to be applied before development reached a certain point, at or beyond which vitality would not be arrested but destroyed. Now I think I am right in saying that no approach even to the necessary conditions can be afforded by any possible state of our sandhills, besides which the moth is equally erratic and appears in exactly the same years in places where no sandhills exist as it does at Wallasey or Deal. It may be admitted however that the supporters of this retarded emergence explanation derive some small support from cases which have occurred with other Lepidopterous pupa, which have been known to "lay over" for several years at a time, but what evidence of fact we have available in the case of *this* species goes in quite the opposite direction. There is no doubt that many thousands of *galii* have been bred from the pupæ by collectors, but there is not one instance on record of a single pupa having ever deferred its emergence a single year. Take this special year 1888 although the larvæ swarmed in that autumn, not a moth or larva was seen in 1889. Due say these theorists to deferred emergence; the pupæ remained as it were dormant and presumably are dormant still. How came it then, that of the great numbers taken by entomologists, every one either emerged the next year or died, while of those left to nature the majority have deferred their emergence for at least four years? It is I think difficult for the supporters of this idea to furnish a satisfactory reply.

I should perhaps not omit to mention that one well

known entomologist whose long experience and practical knowledge we all admit and admire seems to me to have rather darkened counsel by an assertion that on the position in which the larvæ pupate, whether with head up or down depends their chance of survival and as I understand the theory, when there are many heads up then we have a good *galii* year, but as to why the great majority of pupæ should be favourably positioned only once in a long series of years, we are not told. This idea seems to me to bear its own refutation on its face, because from everything we know of nature it is certain that were any special position of the pupa necessary for normal development, that and no other would be the position adopted.

Now what conclusion can be derived from all this? So far I have attempted to demonstrate that all those theories which explain the erratic abundance of *galii* by foreign immigration of any kind, not only are theoretically unsound and unsupported by any evidence in fact, but that what evidence we have on the subject at all goes dead against any such hypothesis and further if these moths do *not* come from over the sea and as we can hardly consider spontaneous generation as an admissible alternative we are forced to the conclusion that where *Deilephila galii* is ever found, there it always exists in greater or less abundance. That I believe to be a true statement, I do *not* think it credible that the pupæ lie hid for years beneath sandhills, I believe that every year *galii* moths emerge, lay their eggs, and ensure an annual succession of the species. And moreover I feel persuaded that the road to the explanation not only of this but of all these phenomenal and irregular appearances among low forms of life lies in a true apprehension of that state of things which has been well named "*The Struggle for Existence.*" I mean the interaction of two very familiar principles: one of which

is that among all low forms of life the capability of increase, the potentiality of enormous and rapid multiplication is exceedingly high, so much so that the mere geometrical increase of even a single pair would theoretically in one, two or three seasons result in far more than the numbers actually produced even on the most favourable occasions of abundance. The other principle being that the waste of immature life is also so immense, the forces of destruction arrayed on every side so active, so unceasing, so innumerable, that of any given species in every year, the actual survivals bear to the possible survivals only the very smallest proportion. That is to say, the number of mature individuals of any species of insect we see around us, represents only the small balance between a vast generative and a vast destructive power, and in its variation is an index not of a variable productive capability on the part of the race, but of a variable application of the agencies of destruction.

Those who have studied any of the lower forms of life, know well what a worse than Mirza's bridge is the course of any such existence, how of the millions of ova laid only the few units struggle into the perfect light of maturity; indeed so imminent so inexorable are the dangers that ever beset all such life that among insects at any rate, the greater part of that variety of structure and appearance which we see so manifest, seems to have been brought about in a great measure by the shifts necessarily resorted to, and the disguises adopted, in order to evade utter destruction. And now to consider the case in the light of this axiom which I consider as the key of the problem. I hold then that *Deilephila galii* never QUITE dies out, I maintain that in the desolate places where this species breeds, the unfrequented coasts, the lonely marshes, the solitary wastes there are far too few observers to

establish anything like a reliable record. For example in that restricted area which we call the Wallasey sandhills, a locality perhaps better watched than any other similar spot; I believe that one hundred moths might exist for a lifetime of normal duration and never be seen at all. But say unmerciful disaster following year after year has brought down their numbers to no more than ten females. A number I indeed hold as absurd, being too near the point of actual extinction which I maintain has never so far been reached. Now credit each female with fifty fertile ova a very moderate allowance and assuming in the progeny an equal proportion of the sexes it is not a difficult calculation to prove that allowing all the ova to reach maturity, only three years would produce the enormous total of 300,000 perfect insects.

But of course the total number of ova laid never do reach maturity, they are ruthlessly mown down in every stage of their career, death dogs their every footstep, birds, mammals, hosts of other insects, spiders, ichneumons beetles, floods, moving sands, disease of all kinds, and last, but not least, entomologists, or rather collectors, when they have the chance, thin their attenuated ranks from the ovum to the perfect insect. And the comparatively few imagines which result represent the balance, the small fraction, between the many that have perished and the slightly more who were born.

Thus then the question seems so far cleared that it is obvious that any diminution or mitigation of the destructive agencies, would in one or a short series of years quite sufficiently account for those seasons of singular abundance without suggesting anything abnormal in the ontogeny of the insect itself.

The next step then in the enquiry is to consider the nature and incidence of these destructive agencies what-

ever they may be. This would appear no easy task when one considers that such forces are as complicated as they are numerous and that many are exceedingly subtle in their influence and, as for instance epidemic diseases, quite outside ordinary methods of investigation. A little consideration however induced me to think that among them all, the *weather* must be one of the most powerful factors, because we find *galii* by no means a rare insect in most parts of the continent, nor does it appear there to be so subject to irregularity of appearance. In fact Great Britain seems to be as it were the very fringe of its range.

Now if the cause of the occasional abundance of this insect here were the temporary cessation of the ravages inflicted upon it by say ichneumons, birds, mice, or even winter floods, or moving sands, or disease except as induced by climatic causes, I can discovered no good reason why such influences should not make themselves felt as much in Germany as in England. But it is evident that the irregular action of the sinister influences whatever they may be are a peculiarity of this favoured isle, and the weather at once suggests itself. Now the only two forms of weather variation which permit themselves to be dealt with at all definitely or systematically are rainfall and temperature.

The accompanying (p. 44) table shows how the four years of *galii* abundance were affected by temperature and rainfall. There are accessible records of temperature of every month since 1814, but as our authentic entomological records do not go beyond 1834 we need not pursue the enquiry beyond that point. The statistics of rainfall are not so complete, the only set I can obtain for my first series of years 1833—1834 are from a British Association report on records taken in York, but the monthly means for all parts of these islands are proportionally very similar,

sufficiently so at any rate for the purpose. One word as to the entomological records,—*Deilephila galii* is a fortunate subject for investigation because its occurrences have almost always been recorded in the entomological serials and they may be taken without hesitation, as this is a species no one could mistake for any other.

In 1834 we hear of the species at Yarmouth, Isle of Wight, Peterborough, and in Somerset. Then a few single specimens from 1835 to 1847 not one from 1847 to 1853 then only two or three records till 1859 when we hear of seventy taken at once on the south coast, forty or fifty at Deal, many at Wallasey, also at Perth, Darlington, Cambridge, Taunton and in Dorset.

After that year two in 1860 and then only three between 1860 and 1869. Then in 1870 we have larvæ taken in hundreds north, south, east and west, Deal, Lancashire, Cheshire, Fifeshire, Northumberland, Sussex, Suffolk, Derby, Herefordshire, and Gloucestershire. In 1871 eighteen larvæ all told then none till 1876, two in that year then only one till 1888 twelve years.

In that year nearly every entomologist filled up his series, they were everywhere where they had ever been.

Now I want to point out before proceeding that nearly all these records refer to the *larvæ.* Probably not fifty imagines of *Deilephila galii* have ever been taken in Great Britain. The years of abundance mean years of *larval abundance.* Therefore I believe that it is during the year previous to the summers when the larvæ are so abundant that we must look for the critical time, the time when some atmospheric condition allowed a survival so very much greater than usual and that the numbers of larvæ which we saw say in September, 1888, were really due to influences at work in 1887 and not materially neutralized in 1888. On this assumption I have arranged

the series as shown starting from the imago of the previous season to that of abundance.

I have added the state the insect would be in during the various months of the season, and the figures at the bottom indicate the monthly means for a period of 50 years. Now let me first confine attention to temperature, and I may as well at once admit that I can get no sort of satisfactory theory out of the temperature figures.

The assumption would seem probable at first sight that temperature at the time of the flight of the imago might affect oviposition. Not at all. June and July are the imago months, and for the purpose of comparison I have singled out two other years in which there were no *galii* seen at all. Now the mean temperature of June, July is 60·6 but in 1869 it was only 54·9 followed by a high average for June, July, 1870, while 1887 was high and 1888 very low: and each of these exactly opposite series results in a *galii* season, while 1868 almost the highest June, July of the century produced nothing.

Similar results are obtained by a consideration of the effect of temperature on any other stage of the insect career. August is the egg month, early September the young, and late September and October the mature larval period. The experience of most entomologists as regards larvæ is that they are extremely susceptible to changes of temperature, yet the larvæ of 1887 must have flourished during September and October months, both two degrees below the mean quite as much as in 1858 when they were nearly four degrees above it.

From the first three series it might well be argued that a high summer temperature at any rate during the second half of the biennial term had a considerable effect; but it stands to reason that similar influences work each year in a similar way, and it is part of my theory that the

phenomena I am investigating are the result of causes operative during one season and not neutralized till the end of the next. Besides this the last series 1887, 1888 seems to uptset any conclusion drawn from a high temperature as although the July, August of 1887 were considerably above the mean, the same months in 1888 were distinctly below it.

Now allow for the sake of argument that the hot summer of 1887 originated the abundance, we must then admit that the very cold summer of 1888 would have checked it, and checked the survivals *before* they reached the adult larval stage in which they were discovered so numerously. But the problem to be solved provides that the check came in when or after the larvæ had reached maturity. Therefore the temperature factor will not solve it. If temperature really had any great effect the series 1868, 1869 or 1884, 1885 should have been "galii" years instead of 1869, 1870 and 1887, 1888.

I admit to some disappointment at this want of result as I felt that a cold summer ought to have had a very marked effect in retarding and a hot one an equal effect in stimulating survivals, affecting as I assumed it might both the summer oviposition and the welfare of the very young larvæ. Thus foiled in my attempt to deduce any decent theory out of Temperature I turned to Rainfall. Now here I do flatter myself that I can trace some sort of principle at work. The lowest figures give the mean of the half century.

And firstly one thing is obvious, the imagines are no more effected by rain than they were by temperature. In June, July, 1888, 5·05 inches of rain fell, while the mean is only 2·21 and the two summers of the biennial 1887-8, giving altogether nearly seven inches of rain resulted in more larvæ than 1869, 1870 when the two summers give

only a little over two inches. The moths then as regards their ovipositing powers seem to be quite indifferent to much or little wet. Then one might naturally surmise that the ova or very young larvæ might be highly susceptible to continued dampness, but we find no evidence of this, in fact there are only two Augusts, (the month of ova and young larvæ) out of all the series, and that the least valuable from an evidential point of view which were particulary dry, I mean 1833, 1834. But now if a later period in the larval life is considered, say the last half of it, we may perhaps discover some sort of uniformity. The *Octobers* of what I believe to be the critical part of the term are dry, uniformily, consistently dry. Only *one* comes to above half the mean of the rainfall of 50 years.

Now I think that it is at least a not untenable hypothesis, to conclude that the mature larva of this moth is particularly susceptible to continued rain and dampness, that such a state of the atmosphere occasions great mortality among these larvæ, that as the months of September and October are nearly always wet with us, there is consequently nearly always a heavy mortality, but that on those very exceptional years when we have a particulary dry autumn, a much greater number of larvæ survive, and that such increased larval survivals result, nothing occurring of a specially detrimental effect meanwhile (and this of course is an important proviso), in an increased number of imagines, and it is the progeny of these imagagines whose numbers arrests our attention and make what we a call *galii* year.

Now it is not necessary that this second brood of larvæ survive; to attest their abundance they have but to exist up to a certain point; therefore if any object that there were wet Octobers in 1859 and 1870 years when the larvæ were abundant, my answer is that I freely admit the wet

Octobers and suggest that such wetness was fatal to the larvæ, because although they lived long enough to be noticeable, they died completely enough to prevent any survivals to the next year.

Again considering the season 1888. It might be asked, if the prevailing cause of the annual destruction which decimates the larvæ of this moth be our usually wet autumns, why the abundance was not carried over to the next year 1889, as the whole of the autumn of 1888 was unusually dry. To such an objection, I would reply that although I believe much rain to be a prevailing I do not maintain that it is the *only* cause. I explain the abundance of the almost mature larvæ during that autumn by its unusual dryness and I think that some other detrimental agency must on that occasion have taken the place of the rain. I fully believe that at Wallasey and Crosby and perhaps at Deal the attentions of collectors had a quite appreciable effect, as the larvæ were abstracted in hundreds if not thousands. Possibly also the extreme difference of temperature between day and night which in dry seasons is always greater than in wet, and is sometimes at the end of September particularly marked, may have had a fatal effect in so susceptible a larvæ; but be the agencies what they might, my point is that the bulk of these larvæ were really destroyed, killed, before they pupated and that the absence of any noticeable descendants in 1889 was due to such destruction and not to the refusal of the pupæ to produce moths at the proper time.

Again although the years in which these larvæ so abounded were distinguished by exceptionally dry antecedent autumns, yet it may easily be objected that within the fifty-five years here embraced there have been quite half a dozen seasons equally distinguisbed by dry antecedent autumns, which have not been "galii" years. That

is perfectly true, but the proposition I am attempting to make good is not that whenever we have a very dry autumn, then during the next year must *galii* necessarily abound but that so far no "galii" year has occurred (that we have any record of) without such a particularly dry antecedent autumn, and that therefore we are not unjustified in provisionally assuming that one of the most potent causes which occasions these seasons of abundance is the increased healthiness and consequent increased larval survivals due to the absence of rain. Why this particular larvæ should be so specially susceptible to wet when adult or nearly so, is a question, which only investigation into its physiology could adequately answer, but a consideration of its habits perhaps tends to confirm such a belief. When young it rather affects the shelter of the galium and seems to feed lower down among the leaves, but the adult larvæ scorn any protection and as Mr. Arkle a local observer quoted by Mr. Dale says, "Are fond of feeding and exposing themselves in the hotest sunshine where the galium grows thin and short." The larva too is quite glabrous and hence probably feels the effect of rain more intimately than do pubescent larvæ. So that from what we know of the nature and habits of this insect itself, we might readily believe that it might be specially affected by rain.

Such then is the conclusion to which my investigation into this interesting subject has led me. I am aware how rash it is to seek to establish any theory in a series of tests so few as are available in this case, besides which, the most superficial examination of all low forms of life cannot fail to impress with a sense of its extreme complexity, its nice mutual adjustments, its infinite interaction and correlation, and I hold in this case that atmospheric is only one of an innumerable array of influences exerted

during every moment of being. I believe it to be with *Deilephila galii* one of the most important but only one among a multitude too delicate to guage and too subtle to detect.

To those entomologists who love to cut the Gordian knot of biological difficulties with the ready sword of some heroic but unsupported theory, and who call *galii*, as the Welsh prince called spirits from the vasty deep, such a conclusion, namely that these abnormal years of abundance may be due principally to nothing more startling than a dry autumn, may seem lame and impotent enough. Whether indeed there may be any other influence at work whose operation I have overlooked, whether there be anything in heaven or earth as touching the economy of *Deilephila galii* undreamt of in our philosophy I am in no position dogmatically to say. I simply submit these investigations and the results I have attempted to deduce from them in the hope that they may to some slight degree help to clear the obscurity, or put on a more rational basis the theories, which have hitherto involved the consideration of the most conspicous and best known instance of this singular phenomenon of the intermittent ebb and flow of racial vitality.

		June, July	Aug.	Sept.	Oct.	Dec., Jan. Feb,	June, July	Aug.	Sep.	Oct.	
		(Imago)	(Ova)	(Larvæ)		(Pupæ)	(Imago)	(Ova)	(Larvæ)		
1833	Temperature	60·6	57·9	53·7	50·7	43·0	62·9	62·7	58·6	50·0	1834
	Rainfall	2·18	1·20	2·17	·70	?	3·03	·89	?	1·27	
1858	Temperature	62·9	62·0	60·3	50·8	38·4	64·7	63·5	56·7	50·9	1859
	Rainfall	2·10	1·50	0·86	1·44	1·12	2·35	1·13	3·80	3·60	
1869	Temperature	58·9	60·8	59·0	48·9	37·5	63·2	61·1	55·7	49·8	1870
	Rainfall	·85	1·21	3·08	1·77	1·60	1·20	2·02	1·63	3·34	
1887	Temperature	63·8	62·5	54·0	45·0	36·9	58·1	59·1	55·7	46·0	1888
	Rainfall	1·26	2·35	2·21	1·03	1·08	5·05	3·73	0·73	1·30	
1868	years in	64·7	63·6	60·5	47·9		54·7	60·8	59·0	48·9	1869
very hot year.	which	·76	2·61	1·52	2·59		·85	1·21	3·08	1·77	
1884	no Galii	60·7	65·3	59·3	48·9		61·6	58·5	55·1	46·1	1885
very dry year.	appeared.	2·0	0·67	2·09	1·04		1·08	1·32	3·73	3·41	
Mean of 50 ys.	Temperature	60·6	61·3	56·8	47·8						
	Rainfall	2·21	2·49	2·25	2·82						

Temperature in degrees Far.
Rainfall in inches.
When two or more months are combined the figures indicate the mean not the sum of the months.

SIXTH ANNUAL REPORT of the LIVERPOOL MARINE BIOLOGY COMMITTEE, and their BIOLOGICAL STATION at PORT ERIN.

By W. A. Herdman, D.Sc., F.R.S.

DERBY PROFESSOR OF NATURAL HISTORY IN UNIVERSITY COLLEGE, LIVERPOOL; CHAIRMAN OF THE LIVERPOOL MARINE BIOLOGY COMMITTEE, AND DIRECTOR OF THE PORT ERIN STATION.

[Read 9th December, 1892.]

Introduction.

As this, although a continuation of the series of Annual Reports dealing largely with the Biological Station on Puffin Island, is also in a sense the opening of a new record, it may help some of those whose sympathy we wish to enlist in the new locality where we have come to work if a brief explanation is given of the object of the Liverpool Marine Biology Committee and of the reason why they have a Station at the Isle of Man.

Biology is the science of living things, and deals with all plants and all animals including man. Used in its proper wide sense Biology includes not only Botany and Zoology, or Natural History, but also Embryology, Palæontology, Anatomy, Physiology and Anthropology. Marine Biology deals with the development, life-history, structure, actions, and relationships of the animals and plants which live in the sea, and also with any general theoretical questions upon which these animals and plants throw any light.

Some of the reasons why marine biology is a favourite subject of investigation, and is so often spoken of apart from other biological studies, are, that animals are much more numerous and more varied in the sea, and especially round the coasts, than upon land or in fresh waters, and represent a larger number of the more important groups;

moreover these marine forms have given rise in the past to the land and fresh water animals, and also to those of the deep sea—they are the parent community from which migrating swarms have been given off; it is amongst these marine animals round coasts that there has been the greatest over-crowding and the most severe struggle for existence, and it is there probably that, under the stress of competition, important new habits and structures have been evolved and modified. Many of the great biological discoveries and generalizations have been made from the study of marine animals, and many of the problems which still await solution, some of them theoretical questions of the greatest general interest, will probably have to be worked out in the abundant and varied material which presents itself to the marine biologist. Then again the sea is so large, and so comparatively unknown that there is much more chance of coming upon interesting new forms of life there than elsewhere.

Finally it should not be forgotten that we are a maritime nation, that we most of us take kindly to the sea, and that we naturally regard it as a duty to thoroughly explore our coast lines, to examine the sea bottom lying off our shores and make known the conditions of existence and the various kinds of plants and animals living within the British Area. Probably these reasons sufficiently account for marine biology having flourished for the last century in this country and for the fact that there have always been amongst British Naturalists, enthusiastic investigators of the sea bottom by means of the dredge and the trawl.

I shall merely add that although Aristotle collected marine animals on the shores of Asia Minor more than 2000 years ago, and it is over a century since the Danish Naturalist O. F. Müller invented a dredge for scientific

purposes, while our own Edward Forbes, most closely associated by birth, training, and in his after work with the Isle of Man, started his pioneer explorations round our coasts quite sixty years ago, yet there is still abundance of work left—an apparently inexhaustible field lies before the skilled observer. In all groups of marine animals investigations of all kinds, faunistic, anatomical, embryological, are urgently needed. Even in the collecting and naming of specimens from our most frequented hunting grounds much remains to be done. To take a recent instance as an example:—a couple of weeks ago when Mr. Thompson and I went for a day's dredging to Port Erin, as we were approaching land we took two last hauls of the small mud dredge close to the shore, the one within a few yards of the biological station the other just along the base of the breakwater, and the contents of the net when examined yielded numerous interesting Cumacea, Amphipoda and Copepoda, three of which latter (*Stenhelia denticulata*, *Laophonte spinosa* and *Ameira attenuata*) are new to science, while several others are rare and interesting forms.

So much for the general question of marine investigation: Biological Stations are a comparatively recent development which were unknown to the older naturalists. Any plan by which actual work on or close to the sea, so that the animals may be examined alive and in their natural surroundings, can be combined with the conveniences and exact methods of a laboratory is obviously a great advantage, and that is precisely what a biological station offers. It is a sea-side laboratory where the observer can conveniently apply the refinements of modern apparatus and re-agents to the work of the field-naturalist. Different Stations may specialize in various directions, but an institution like our Biological Station at Port Erin has I

consider at least two important functions which it can perform :—(1) It can supply material and afford opportunities for their investigations to the Committee and to other specialists and so be a means of adding to knowledge, and (2) it will enable advanced science students and young graduates from our Colleges to become acquainted with marine animals in the living state, and in various stages of development, and will stimulate them to, and give them opportunities of commencing, research work.

The Liverpool Marine Biology Committee was instituted in 1885 for the purpose of investigating scientifically the Fauna and Flora of Liverpool Bay and the neighbouring parts of the Irish Sea, an area usually referred to for

Fig. 1. Map of the L.M.B.C. District. H, Hilbre Id., P, Puffin Id., E, Port Erin.

short as the L.M.B.C. district. The Committee established a small biological station on Puffin Island off the North coast of Anglesey, in 1887; and for the last five years this station has been kept up, and constant dredging and

other exploring expeditions have been carried on, as the result of which three illustrated volumes of reports have already been published ("Fauna of Liverpool Bay," vols. I—III.). The Puffin Island establishment has been very useful to the Committee, and well worth the small annual expenditure required for its modest outfit. It has been used by some students of the local Colleges who wished to gain a general knowledge of the common marine animals and plants in a living state, and by a considerable number of specialists who went there to make observations, or who had the material for their investigations collected there and sent to them.

It has been felt however by the Committee for some time that a station which was more readily accessible from Liverpool, and with hotel or lodging accommodation on the spot, would enable their specialists to do more work, and be of more use to students and investigators generally. Also it was becoming evident that after five years work on the shores of the small island the greater number of

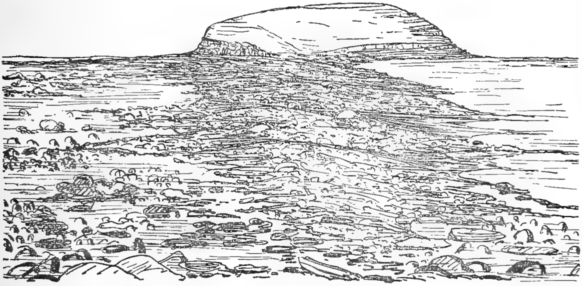


Fig. 2. Collecting ground at Puffin Island.

the plants and animals had been collected and examined, and that a change to a new locality with a rich fauna and a more extended and varied line of coast would yield

increased material for faunistic work; and, consequently, in the last annual report (December, 1891) it was suggested that the time had arrived when the Biological Station then on Puffin Island might with advantage be transferred to some new and less inaccessible spot. Hoylake or West Kirby in Cheshire and Port Erin in the Isle of Man were both mentioned as suitable, and a free expression of opinion from local biologists was invited, with the result that it soon became evident to the Committee that our workers almost unanimously voted for the south end of the Isle of Man.

On communicating with the Isle of Man Natural History and Antiquarian Society through their energetic Secretary Mr. P. M. C. Kermode, of Ramsey, we were gratified to find that they welcomed our project, and passed the following resolution at their meeting on February 25th :— "On the strong recommendation of the General Committee, it was unanimously resolved that Professor Herdman be invited to establish a Marine Biological Laboratory in the island, and that this Society should afford all the assistance in its power to an undertaking which would be of so great an advantage to it and to the whole island, and would consider it an honour to co-operate with the L.M.B.C. in their excellent work" (see YN LIOAR MANNINAGH, vol. I., no. 11, p. 368.)

As it was felt to be highly desirable that the laboratory should be open and ready for work as early as possible in summer, Mr. Thompson and I went over on a mission to Port Erin and Port St. Mary early in March for the purpose of finding out what places were available at that end of the island. After examining various existing buildings at Port St. Mary, Perwick Bay, and other places, we fixed upon a most suitable site at Port Erin, and were fortunately able to arrange with the owner Mr. Thomas

Clague of the Bellevue Hotel, that a biological station of three rooms should be erected, of which the Committee would take a lease. The Committee desire to express their appreciation of the public spirit and enterprise which Mr. Clague has shown, the readiness with which he has met their views, and the trouble he has taken to see the whole work satisfactorily carried out.

Fig. 3. Stack Rock, Calf Sound, near Port Erin.

After returning to Liverpool I prepared detailed plans of the proposed biological station which, after being sanctioned by the executive of the Committee, were transmitted to the builder. The work was commenced on April 20th, and finished in every detail, including the internal fittings and varnishing of the woodwork, a couple of days before

the opening on June 4th. A short description of the station and its surroundings may be appropriately placed on record here.

Port Erin and Neighbourhood.

Port Erin is at the S.W. end of the Isle of Man and occupies a fairly central position in the Irish Sea, being about 30 miles from Ireland, 33 from Scotland, 40 from Wales, and 45 or so from England. The bay faces nearly due West, and is in most winds a good natural harbour with sand at the end and bounded by precipitous cliffs both to North and South. From its position and the shape of the land, Port Erin has within a distance of a couple of miles in three directions—to Fleswick Bay, to the Calf Island, and to Port St. Mary—a long and varied coast line with a number of small bays, furnishing good collecting ground and shallow water dredging. Two of these bays, Port Erin and Port St. Mary, have harbours with sailing boats, and face in nearly opposite directions, so that in most winds one or other is sheltered and has a quiet sea.

The rich fauna around the Calf Island and off Spanish Head (see map, Pl. I.) is within easy reach; while at a distance of three to four miles from the biological station are depths of 20 to 30 fathoms, and at 14 miles 60 to 70 fathoms. Although Port Erin is a considerable distance from Liverpool, still it is reached by a regular service of swift steamers and convenient trains, so that there is no great uncertainty or delay in the journey. The 11.30 a.m. steamer from Liverpool to Douglas generally catches the 3.50 train in summer and the 5.30 in winter, arriving at Port Erin in each case an hour later.

The plan of Port Erin bay (Pl. II.) shows the position and surroundings of the Biological Station. (See also

view, Pl. III.) It is on the beach at one corner of the bay, near where the sand and rocks meet, and at the foot of the cliff upon which the Bellevue Hotel stands. It is connected with the highroad by means of a broad zig-zag gravel walk and concrete steps, and is only about one third of a mile from the railway station. It is just at the bottom of the hotel grounds, and arrangements have been made with Mr. Clague by which those working at the Biological Station can live comfortably and economically at a fixed tariff at the hotel.

Fig. 4. Liverpool Marine Biological Station at Port Erin.

The sea comes to within a few yards of the windows of the Station, and the bay immediately in front is sheltered, pure sea water with a varied bottom suitable for small boat dredging and tow-netting; while the rocky coast,

extending out towards Bradda Head, has many creeks and good shore pools containing an abundant stock of interesting animals belonging to various invertebrate groups.

The Biological Station is a substantially built, three roomed house, measuring a little over 30 feet by 20 feet, and standing on a solid stone and concrete platform, which raises it about 10 feet above high tide. It has windows looking out in three directions, north, south, and west. The front door (see Pl. IV.) leads into a short passage from which open to right and left two small rooms (6 and 7) which are used as the Director's room and library and the Secretary's office, and will also be available for the use of any members of the committee or any special investigators who from the nature of their work require a separate room where they can have privacy and can set up delicate apparatus or leave their specimens in safety. The secretary's office is also now being made light-tight, and fitted with screens to the window so that it can be used as a photographic dark room.

Opposite the entrance is the door into the main laboratory, which measures about 22 ft. by 20 ft., and has windows on both sides. In front of the windows run strong fixed work-tables which will accommodate half a dozen students with ease, ten at a pinch. So the greatest number who can work in the station at one time when crowded is a dozen, while half a dozen fill it comfortably. At the two ends of the main laboratory are fire-place, sink, tables, closed cupboard, and abundance of shelving; while along the centre of the room runs a strong table for small aquaria, and vessels containing animals. A door in one corner opens into a useful small yard between the house and the cliff, in which the concrete fresh water cistern supplying the laboratory sink is placed,

and where dredges and other implements can be stored.

The Committee purposely did not arrange for any larger fixed aquaria or tanks in the laboratory as they desired to have the experience of a summer's work before deciding whether any such were necessary, and if so where they should be placed. It is now generally agreed that the station is so near to the sea, and pure water is so easily obtained when required, that it does not seem worth while to introduce pipes and a pump; while all the space in the laboratory is so useful that we can ill afford to occupy any of it with fixed tanks. There is, however, a small plot of ground alongside, on the western side of the steps leading to the beach, and just opposite the front door of the station, which might be used for the erection of a small aquarium and tank house. There is also, on the beach close to, a large rock pool placed in such a position between two reefs and the shore above that by the erection of three comparatively small concrete walls of no great height, and lying in a sheltered position, a pool having a length of about 40 feet and a breadth of from 12 to 18 feet and about 6 feet deep in the centre could readily be formed (see Pl. V.). Such a pool as this, into which the sea could be admitted or not as required at each tide through a sluice in one of the walls, would be of great service for keeping larger animals in, and might be made use of for spawning fish if the Lancashire Sea-Fisheries Committee decide to establish a small fish-hatchery alongside our biological station.

The Inauguration of the Station.

Towards the end of May when the building was nearly completed, it was decided by the Committee that it was due as well to their supporters in Liverpool as to the inhabitants of the Isle of Man, amongs whom they were

going to work, that the institution should be formally inaugurated. His Excellency the Lieutenant-Governor was approached on the matter, and he kindly consented to open the biological station on Saturday, June 4th, while the Lord Bishop, the Manx Attorney General, and a number of members of the House of Keys and other representative men in the Island were good enough to promise to attend the ceremony and take part in the luncheon at the Bellevue Hotel which was to follow. A circular drawing attention to the completion of the station and giving an outline of the proposed arrangements at the opening was issued privately to naturalists and their friends in the neighbourhood, and as a response a party of over 30, consisting of members of the committee, a few other scientific men, and some of the subscribers to the funds, crossed over from Liverpool for the occasion.

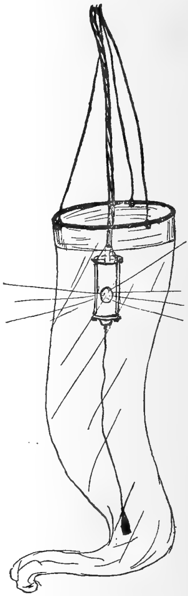


Fig. 5. Submarine electric light in tow-net.

The Liverpool Salvage Association, with their unfailing kindness, had been good enough to promise to lend their useful steamer the "Hyæna" for four or five days at that time, but as she was called off on duty at the last moment, they sent instead the steamer "Mallard" (under the command of Captain Batchelor of the Salvage Association), on the Friday afternoon, across to Port Erin, where she remained till Monday. Dredging trips in the neighbourhood took place on three of the days, and on the Saturday evening tow-netting with

submarine electric lights was carried on after dark in the bay.

Most of the Liverpool party arrived at Port Erin on the Friday afternoon for the purpose of completing the preparations for the opening, such as hanging diagrams and charts on the walls of the laboratory and unpacking the vessels and instruments. During the following forenoon all were busily engaged in collecting specimens. A party went out dredging towards the Calf Island in the "Mallard," others worked from a small boat in the bay, while others searched the shore pools in the immediate neighbourhood. The specimens were brought alive to the laboratory and arranged in the aquaria and dishes and under microscopes in order that the visitors in the afternoon might see the place as far as possible in working order and gain an intelligent idea of the objects and methods of marine biological investigation. The following account of the more public functions of the day, the opening ceremony and the luncheon, is extracted, with some abbreviation, from the daily papers.*

"His Excellency the Lieutenant-Governor, Spencer Walpole, Esq., LL.D., and the Lord Bishop of Sodor and Man, Dr. Straton, were met at the Port Erin Railway Station shortly before 1 o'clock by the following members of the L.M.B.C., Prof. Herdman (Director), Mr. I. C. Thompson (Hon. Sec.), Sir James Poole, Mr. J. Vicars (Mayor of Bootle), Mr. A. O. Walker, Mr. A. Leicester, Mr. R. J. Harvey Gibson, and a number of other naturalists including Mr. A. W. Moore, President, and Mr. P. M. C. Kermode, Secretary of the Isle of Man Natural History and Antiquarian Society. The Governor was accompanied by Miss Walpole; and Sir James Gell, Mr. J. S. Gell, Dr. Walters, and a number of other gentlemen and ladies from various parts of the island soon joined the party which then proceeded to the Bellevue Hotel, the road to which and down to the Biological Station on the shore was lined with flags and other decorations.

The little station at the foot of the cliff was soon reached, and on the

* See "Isle of Man Times," &c., for June 11th, Liverpool "Daily Post" and "Mercury" for June 6th, and "Nature" for June 16th, 1892.

permanent platform outside the laboratory there assembled a considerable company. In addition to his Excellency, the Bishop, Professor Herdman, and Mr. Thompson, the company included Sir James Poole (ex-Mayor of Liverpool), the Mayor of Bootle, Professor Weiss (Manchester), Professor Denny (Sheffield), Messrs. A. O. Walker (Colwyn Bay), P. F. Kendall (Manchester), Arnold Watson, R. Ascroft, N. Caine, R. J. Harvey Gibson, J. Lomas, A. Leicester (Liverpool), the Attorney-General of the Island (Sir James Gell), Mr. James Gell (High Bailiff, Castletown), the Rev. F. B. Walters (principal of King William's College), Dr. Clague (surgeon to his Excellency's household), the Revs. E. Ferrier, M.A., A. Newton, B. Brown, C. H. Leece, H. T. E. Barlow (principal of the Bishop Wilson Theological School, Bishop's Court), and A. Kermode (vicar of Onchan), Messrs. W. A. Stevenson, H.K., W. Quine, H K., W. B. Stevenson, A. W. Moore, H.K., P. M. C. Kermode, (secretary of the Isle of Man Natural History and Antiquarian Society), F. Gaskell (Liverpool), A. R. Dwerryhouse, A. F. Dumergue, M. Lamart, W. S. Henderson, S. R. Christopher, Capt. Nowell, R. Garside, W. Shimmin, C. T. C. Callow, Capt. Batchelor, H. Williams, R. Craig, W. R. Wareing. J. Coventry, Dr. Hanitsch, Dr. Ellis, Professor Stevenson, G. H. Quayle, J. C. Crellin, H.K., H. Kelly, J. Clague, C. Squires, T. Clague, T. Costain, E. Allen, J. McArd, R. Moore, W. Davidson, Aylmer Ogden, &c., &c., and a number of ladies.

Professor Herdman then, on behalf of the L.M.B.C., addressed the Governor, and having made brief reference to the object of their biological investigations, asked him to accept the volumes already published on the "Fauna and Flora of Liverpool Bay," and having also presented His Excellency and the Bishop, each with a specially bound copy of the collected annual reports upon the former station at Puffin Island, requested the Governor to declare the station open for scientific work.

The Governor said :—Professor Herdman, my lord, ladies, and gentlemen, —I have, in the first instance, to express to you, sir, and to your Committee, my thanks for presenting me with these volumes, the contents of which I am sure I shall read with interest and advantage ; they will remind us, at any rate, that you, who have come here to-day, have done much to promote that cause of biological science to which this station is to be devoted. In your station at Puffin Island, on the coast of Anglesey, as I know from reading your reports, you have done much to illustrate this science. You have moved now from the Mona of Tacitus to the Mona of Cæsar—(hear, hear, and applause,)—and having exhausted, as I believe you have done, the fauna of the Menai Straits, you have come to this Island, where the population has for centuries had a deep stake in the harvest of the sea, and where I believe you will find that our fauna is enriched by those warm currents that find their way hither from the vast Atlantic Ocean. Some of you may possibly imagine

that work of this character is only of minor importance—that it is not a great matter to make some addition to the long catalogue of our Algæ, or to add a new variety to our lists of the Annelids; but then I may remind you that most of the great inventions and discoveries of the world have been almost accidentally found by men, like yourselves, labouring only in the cause of truth, and that every advance in our knowledge adds to the power of mankind, and raises him a little higher from the brute, a little nearer towards the angel. It is, then, both our duty and our interest to welcome—as on behalf of the people of this Island I do venture to welcome—you here who are working in the cause of truth, and I may say that whatever may be your own labours, or whatever revelations you may have in store for us, we may be at least certain that as a result of your discoveries truth will prevail; for it is as true now as it was in the days of Darius—if I may quote one of the noblest passages in the realm of literature, which has unfortunately been excluded from our Bibles—that truth is strongest. "As for the truth, it endureth and is always strong, it liveth and conquereth for evermore." (Hear, hear). I have great pleasure in declaring this biological station open. (Loud applause).

The Governor then opened the door of the building, and the party entered and made a minute inspection of the premises, and its biological treasures and apparatus, and after recording their names in the visitors' book, an adjournment was made to the Bellevue Hotel, for luncheon, which was served up in excellent style by Mr. Clague. Professor Herdman presided, and was supported right and left by his Excellency and the Bishop. Mr. Thompson was the chairman *vis-a-vis*. The Menu was as follows :—

SYSTEMA EPULARUM.

"Infusio" (sive Jūs)—Cauda bovina.

Pisces—Gadus morrhua (Ostrea edulis).

Aves—Gallus bankivus, var. domest. (tost.—decoq.)

Mammalia—Bos taurus, var. monensis.

Ovis aries (Capparis spinosa)

Do., juv.

Crustacea—Homarus vulgaris (Lactuca scariola, var.)

Amorphozoa—Puddings, Custards.

Plantæ—Fruit-tarts.

Incertæ sedis—Jellies, Blancmange.

Varia—Desert, Nicotiana tabacum, Caffea Arabica.

The toast list was as follows :—"The Queen," proposed by the chairman, (Professor Herdman); "His Excellency the Lieutenant-Governor," proposed by the chairman, responded to by His Excellency; "The Lord Bishop of Sodor and Man," proposed by Sir James Poole, responded to by the Bishop; "The Legislature of the Isle of Man," proposed by Mr. A. O. Walker, J.P., responded to by Mr. W. A. Stevenson, H.K.; "The Isle of Man Natural

History and Antiquarian Society," proposed by the Mayor of Bootle, responded to by Mr. A. W. Moore, president, and Mr. P. M. C. Kermode, hon. secretary; "The Liverpool Marine-Biology Committee," proposed by the Lieutenant-Governor, responded to by Professor Herdman, chairman, and Mr. Thompson, hon. sec.; "The Manx Fisheries." proposed by Mr. R. L. Ascroft, of the Lancashire Sea-fisheries, responded to by Mr. R. Garside; "The Liverpool Salvage Association and other Visitors," proposed by Mr. R. J. Harvey Gibson, responded to by Captain Batchelor, and Professor Weiss.

In proposing the health of the Lieutenant-Governor, Professor Herdman pointed out that they welcomed and honoured his Excellency, not only as the representative of the Queen in the island, but also as a biologist, and alluded to Mr. Spencer Walpole's former connection with Huxley and Buckland, as one of H. M. Inspectors of Fisheries. He considered it a particularly happy conjunction of circumstances, that they should have happened to establish that marine biological station on a spot which had been rendered classic ground by the labours of that pioneer of British Marine Biology, Professor Edward Forbes, at a time when by rare good fortune the governor of the island is himself a biologist, (applause). It was exactly sixty years since Forbes, then a student at Edinburgh University, returned in summer to his home in the Isle of Man to commence his work on British Marine Biology (applause). He hoped the coincidence was a happy augury, and that as Edward Forbes had started marine investigation on this spot just 60 years ago, so that day Spencer Walpole had opened an institution which would do much to advance the study of marine biology in the Isle of Man.

His Excellency said :—Mr. Chairman, my lord, and gentlemen, I assure you, sir, I thank you very heartily for the much too flattering terms in which you have commended my name to this gathering, and I thank you all very heartily for the kindly way in which you have received it. I believe that it is a function of the Governor of the Isle of Man to be, in some respects, a "Jack of all trades," and I hope sometimes that it is not consequent upon that function that he should be "master of none." (Laughter). You have rightly reminded me that I have had in former days to deal with other subjects connected with your own, and I still continue to take a deep interest in them; but if I were at all disposed to be puffed up by the kindness of your greeting to day, perhaps I should find the best antidote to any feelings of pride in pondering over those specimens which we have lately been examining in your laboratory, for, I suppose that in the presence of biologists I may assume that they are the nearest living representatives of our own immediate ancestors (laughter), and I sometimes think that though we hear nowadays that we are living in the best of all possible times, yet a good deal is to be said in favour of that simple and primitive form of existence which those specimens remind us is still surviving in the sea. (Hear, hear, and laughter). I am quite sure in those days,

for example, that the art of government was a good deal simpler, whilst the Socialists of that time had established a perfect Communism; and though they had no ideas of property, they were free from all those difficulties to which property unfortunately gives rise. (Laughter and applause). They must, nevertheless, have succeeded in establishing a fixity of tenure. (Renewed laughter and applause). Perhaps, in view of the heated atmosphere of this room, it might also have been some satisfaction to reflect, that in those days there were not the ordeals of public luncheons, or, at any rate, if there were public luncheons, the fare was a good deal more frugal, and a good deal more wholesome than that which we have partaken of to-day. (Laughter and applause). In fact, Mr. Chairman, I have often thought myself that there was a great deal to be said for that view which Miss Kendall has so admirably expressed in "The Lay of the Trilobite." I should think that every biologist ought to be acquainted with that poem. One of the inferior members of the human family was walking across a mountain, I may remind you, when he came upon an ancient Trilobite, upon his rocky bed, and the Trilobite, if I may quote the lines, addressed him in some such words as these. He reminded him

"How all your faiths are ghosts and dreams, how in the silent sea
Your ancestors were monotremes, whatever these may be.
You've politics to make you fight, and utter exclamations;
You've cannon, too, and dynamite, to civilise the nations.
The side that makes the loudest din is surest to be right;
And Oh! a pretty fix you're in, remarked the Trilobite."*

And if you recollect, the man, being somewhat of a philosopher, takes off his hat to the Trilobite and walks away, and as he goes away, utters some such words as these:—

"I wish our brains were not so good, I wish our skulls were thicker,
I wish that Evolution could have stopped a little quicker;
For, Oh! it was a happy plight, of liberty and ease,
To be a simple Trilobite in the Silurian seas." (Loud applause).

Sir James Poole gave "The health of the Bishop of Sodor and Man," and the Bishop, in reply, said in the course of an interesting speech, that the scientist and the theologian should go hand in hand (applause.) He welcomed the Biological Committee to the island, in the name of religion, and of the Church of England, and he hoped that ere long he would have the pleasure of welcoming the Members to Bishop's Court, as he now welcomed the cause they represented.

Mr. A. O. Walker, J.P., proposed "The Legislature of the Isle of Man, which was responded to by Mr. W. A. Stevenson, H.K.

* "Dreams to Sell," by May Kendall: London, 1887, p. 8, slightly altered.

The Mayor of Bootle, (Mr. J. Vicars,) proposed "The Isle of Man Natural History and Antiquarian Society," Mr. A. W. Moore, President, and Mr. Kermode, Secretary, acknowledged the toast. The former expressed the hope that the investigations of the biologists might result in bringing back the herring, which had deserted the island.

His Excellency, in giving "Success to the Liverpool Marine Biology Committee," said : I have ventured once to-day, already, to say something as to the virtue of research for truth for truth's sake, but I do not know that such research need hinder you also from research into those practical objects with which the inhabitants of the Isle of Man and of the whole British Islands are so closely identified. Mr. Moore has alluded to the disappearance of the herring from these shores. I think that was an exaggerated form of words. I ate one of them for breakfast this morning. (Laughter). But there is no subject to which Marine Biologists could better devote themselves than to trace the causes which govern the migration of the herrings, considering how those migrations do govern the prosperity of the fishermen. (Hear, hear.) I need hardly remind you that there is no fish which produces so much wealth to the United Kingdom as the herring, while in this Island the herring assumes an absolutely national importance. We have towns in this Island built out of the profits of the herring fishery. We have large numbers of the population dependent on the herring fishery ; and so strong is the connection between the herring and the Island, that actually to this day, when we swear in a new judge, we always require him to administer justice as evenly as the backbone of the herring lies in the fish—(laughter)—a symbol which I may say parenthetically, was, I imagine, drawn by a fisherman and not by a scientist, because there is some little doubt about whether the backbone does lie evenly in the body of the herring. (Laughter and applause).

Now there is this that is remarkable about the herring. If you go to any portion of the United Kingdom, or this Island, you will always hear complaints that the herring are disappearing, and if you examine any statistics connected with the herring fishery, you will find that taking ten years by ten years, the prodigious capture of the herring has gone on steadily increasing. (Laughter). Facts, therefore, are rather opposed to theory in this case, and in fact I know of nothing more instructive than to open the herring, or when you are munching the hard roe, to try and count the number of eggs. (laughter). I think for one when you have failed in that attempt, as you will fail, you will find a new proof that the old fiat is as true as when it was first pronounced, "let the waters bring forth abundantly the many creatures that have life." But if it is not true that the herring is decreasing, it is true that there are variations in the migration of the herring, which are seriously affecting the fishermen. (Hear, hear). If you ask the fishermen, you will gather the most fanciful reasons for these migrations. I recollect once being

seriously told by a fisherman, who complained that the herring had disappeared from a portion of the coast, that we should find the reason for its disappearance in—I think it is the third verse of the fourth chapter of Hosea. (Laughter). I thought that man at any rate, in an age of doubt, had the capacity of belief. (Renewed laughter). But there is no subject to which I could better draw your practical attention than to expound to us the reasons for the migration of the herring, and to point out to the fishermen the conditions, whether of temperature, of weather, or of food with which they should be acquainted, and which should direct them where to go to reap that great harvest of the sea, which, depend upon it, is supplied us as bountifully now as ever. In directing this subject to your notice, I feel that I am leaving it in worthy hands, and that the researches that Professor Herdman and you have made in the past, afford confident assurance of what you may do in the future. (Applause). In coupling this toast with Professor Herdman's name, I hope you will allow me to congratulate him upon the notice which I read in the *Times* of yesterday, that the Royal Society has admitted him into that charmed circle which has so many attractions for men of science. (Loud applause). Without more words, for trains wait for no man, after a certain time, even in the Isle of Man (laughter) I give you the "Liverpool Marine Biology Committee," coupled with the names of Professor Herdman, and Mr. Thompson.

Professor Herdman, in reply to the toast, said : Your Excellency, my Lord Bishop, and Gentlemen,—As Chairman of the Liverpool Marine Biology Committee, whose success and continued prosperity you have so kindly toasted, I beg to thank your Excellency, and you all, gentlemen, for your kind words and your good wishes, and to tell you how grateful we are, as a Committee, for the honour you have done us, and for this inspiriting encouragement, and how we hope by our work in the future, to show that we have profited by your support to-day, and have been stirred up to fresh efforts by your appreciation of our work in the past (applause).

It is now just seven years since this committee was established. It originated in a meeting in March, 1885, held in University College, Liverpool, at which were present the representatives of the colleges, museums, and scientific societies of several neighbouring towns. I pointed out on that occasion how much good work might be done by a number of specialists working together at marine biology, and laid before the meeting the proposal that we should form ourselves into a committee for the purpose of investigating thoroughly the fauna and flora of the neighbouring seas. As the sea shores in the neighbourhood of Liverpool are unfortunately not so prolific of life and interesting to the naturalist, as your beautiful coast here, most of our work during the past six years, has had to be done from steamboats on dredging expeditions. Fortunately, we have had the sympathy and welcome support of some of the

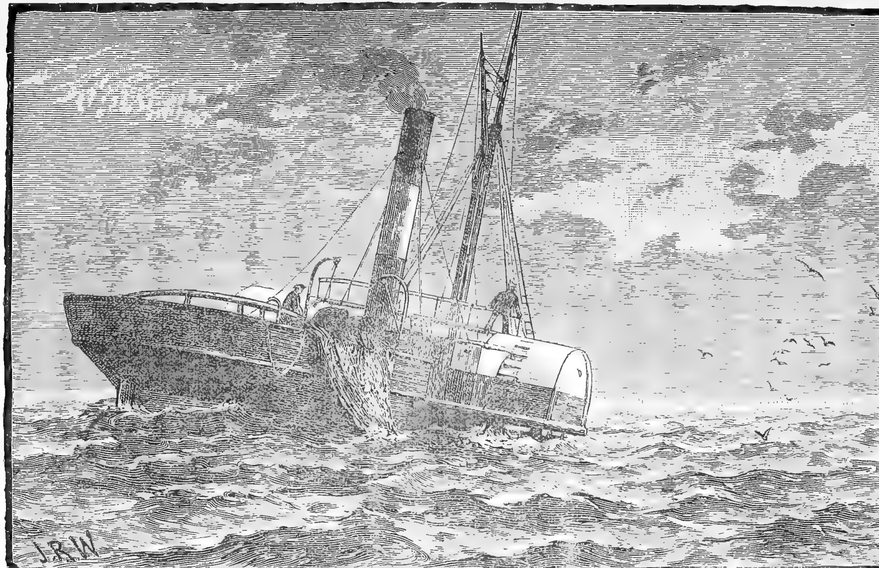


Fig. 6. Dredging from a steam tug in Liverpool Bay.

Liverpool Merchants and Ship-owners, who have kindly helped us by providing on various occasions, steam-tugs for our dredging trips. We have more than once been favoured in this way by our good friend Sir James Poole, whom we are delighted to have again with us to-day. (Applause).

We have also been aided most materially in our movement by the Liverpool Salvage Association, who have lent us in successive years at this time their useful and sturdy old gunboat the "Hyæna," whose graceful form you have seen more than once in Port Erin Bay (applause). I do not know whether you are all aware what a celebrated craft she is. Do you know that she was built for the Crimea, nearly forty years ago, along with a batch—perhaps one ought to call them a "litter,"—of other mammalia, the "Porcupine," the "Jackal," and others? Do you know that she was General Gordon's own gunboat during the war in China, when he pursued the rebels up the shallow rivers, and ran the "Hyæna" ashore on the mud banks in order to blow up their forts? And now, in her peaceful old age, she is lent by her present owners to certain enthusiastic biologists, who haul in dredges and other strange instruments over her low rounded stern, and send her electric lights in nets down to the bottom of the sea, for the purpose of capturing new and rare animals, and they succeed too, for is not one of their interesting new animals named ***Jonesiella** Hyænæ*, in honour of the old gunboat?

As a result of our successive expeditions in the Hyæna, and in other ways, our Committee has been enabled to achieve a very considerable measure of success. We have published a number of lengthy reports upon the various groups of animals in our district, and, lastly, we have established and kept up for five years, a small marine biology station on Puffin Island. The Puffin Island establishment has been of very great service to us, but during the last year or so we have, I think, all felt that the time had arrived when it would be an advantage to move our centre of operations to some less inaccessible spot in a new part of the area. Naturally our choice was determined by the rich marine fauna round this southern end of the Isle of Man, and that brings us down to the present time, and to the little laboratory which has been opened for work to-day. I must not conclude, however, without referring gratefully on the part of the committee to our host of the Bellevue, our landlord of the biological station, Mr. Clague, for his helpful assistance and energetic support. Remember it was only on March 6th, that Mr. Thompson and I came over here to inspect and to decide whether Port Erin, Port St. Mary, or Castletown would be best suited for our purposes. We were happily directed to Mr. Clague, and it is mainly due to his energetic action that the station has been so speedily completed (Applause). I thank you all, on behalf of the Committee, for your kind wishes, and for the support you are giving us in our work. (Applause).

Mr. I. C. Thompson said—The biological aspect of the work of the

Liverpool Marine Biology Committee has been so well put before us by Professor Herdman that I need only appear before you as that obnoxious individual, the practical man, and make a few remarks as to our proposed arrangements for workers at the laboratory rather in the way of the *argumentum ad pocketum.* Hitherto the work of the committee has been mainly supported by subscriptions and donations from our philanthropic friends interested in the work done, but not themselves actual workers, and we trust for an increased continuance of this most valued source of income. But we anticipate that the beautiful and very accessible Marine Laboratory to-day opened by his Excellency will attract a large number of working naturalists and students both belonging to the Isle of Man and from various parts of England who may frequently come for a few days or weeks at a time. It is proposed that all such should have the use of the station as workers for a payment of 10s. per week, and it is further proposed that all annual subscribers of one guinea and upwards shall have free access to the station and the use of a working table at any time provided it be unoccupied—a record of all work done being kept.

A month ago I visited the palatial marine station at Naples, and there saw English and foreign students at work. Now, there is no doubt a great advantage in studying the marine fauna of other districts, and a visit to Naples will repay any one ; but we happily know that Mona's Isle offers most unusual advantages for this work as was amply shown by Edward Forbes, and later by the work of our own committee, and I doubt if anywhere in the United Kingdom we can now find a richer hunting ground, or a laboratory with such beautiful surroundings as at the Port Erin Biological Station. I sincerely thank your Excellency, and you gentlemen, for the hearty way in which you have proposed and honoured this toast, and I trust that we may have many other happy reunions between our Manx and English naturalists. (Applause).

The toast of "the Manx Fisheries" was proposed by Mr. R. L. Ascroft, of the Lancashire Sea Fisheries Committee, and responded to by Mr. R. Garside who gave some interesting details in regard to the Isle of Man Fisheries and the Manx fishing fleet now working off the south coast of Ireland. "The Liverpool Salvage Association and other Visitors" was proposed by Mr. R. J. Harvey Gibson, and responded to by Captain Batchelor of the Salvage Association and by Professor Weiss of Owens College, Manchester.

The proceedings throughout were of a very inspiriting nature, and in the evening the party went on board the "Mallard" for a dredging expedition in the bay, when tow-netting, both surface and bottom was conducted by means of the electric light."

Dredging Expeditions.

On June 5th the whole day was spent in dredging and tow-netting from the "Mallard" (under the charge of Captain Batchelor of the Salvage Association) to the West and South of Port Erin, at the following localities:—

1. Three miles West of Fleswick, 20 fms., 6 hauls of the dredge; good varied ground, old shells, &c. Amongst the species obtained were:—*Halisarca dujardinii*, *Suberites domuncula*, *Clathria seriata*, *Aplysilla* (?) *sulphurea* (*green*), *Sarcodictyon catenata*, *Sertularella tenella*,* *Diphasia pinaster*,* *Cellaria fistulosa*, *Carinella linearis*, *Palmipes membranaceus*, *Porania pulvillus*, *Stichaster roseus*, *Balanus porcatus*, *Xantho rivulosa*, *Atelecyclus septemdentatus*, *Crania anomala*, *Pandora inæquivalvis*, *Pecten striatus*.

2. Fourteen miles West of Dalby, 60 fms., 2 hauls of dredge; bottom sticky blue clay-mud†: here were found, *Lagena hertwigiana*,* *Jaculella acuta*, *Hyperammina arborescens*, *Plumularia catharina*, *Brissus lyrifer*, *Panthalis œrstedi*,* (a representative of the rare family Acœtidæ. This addition to our local fauna has only been once before taken in British Seas, by Dr. Gwyn Jeffreys, 35 miles off the Skerries, Shetland, depth 75 fms.—as recorded by Prof. M'Intosh), thirty species of Polyzoa including *Beania mirabilis*, *Cellaria fistulosa*, *C. sinuosa*, and *Stomatopora granulata*.*

3. Eight miles West of Fleswick, 33 fms., 3 hauls of dredge; here were, *Sarcodictyon catenata*, *Aglaophenia myriophyllum*, *Diphasia pinaster*,* *Echinocyamus pusillus*,

* New to the district.

† The presence of this clay-mud in this deep depression of the Irish Sea may possibly—if it can be regarded as a glacial deposit—be considered confirmatory of the theory of glaciation of this neighbourhood held by the Glacialists' Association, according to which there was a great movement of ice through the North Channel, and downwards between Ireland and the Isle of Man to St. George's Channel, and so out to sea.

Malmgrenia castanea on *Spatangus purpureus*, *Membranipora trifolium*,* *Schizoporella simplex*,* *Melphidippa macra*, *Podocerus minutus*, *Cyproidea damnoniensis*, *Amphilochoides odontonyx*,* *Pseudocuma* sp. (probably new to science), *Balanus porcatus*, *Erythrops pygmæa*, *Atelecyclus septemdentatus*.

4. Six miles West of Port Erin, 24 fms., 2 hauls of dredge :—*Stichaster roseus*, *Amphidotus cordatus* and *A. flavescens*, *Thyone drummondii*, *Siphonostomum affinis*, Sars (which Mr. Hornell considers distinct from *S. diplochaitos*), *Crania anomala*, *Lilljeborgia pallida*, *Mæra semiserrata*, *Thia polita*, *Capulus hungaricus*, *Trochus millegranus*, *Lima hians*, *L. elliptica*, *Ascidia virginea*, *A. venosa*, *Styela grossularia*.

5. One mile West of Calf Island, 20 fms., 2 hauls of dredge :—*Schizoporella linearis*,* *Hippothoa flagellum*,* *Pecten pusio*, *P. tigrinus*, *P. varius*, *Tellina crassa*, *Solecurtus antiquatus*, *Odostomia scalaris*,* *Defrancia teres*.*

6. Off Kitterland, West end of Calf Sound, 17 fms., 1 haul of dredge; *Adamsia palliata*, *Lepton sulcatulum*,* *Cyclostrema cutlerianum*,* and *C. nitens*,* *Odostomia nitidissima*,* and *O. acicula*,* *Eulima bilineata*.*

At each of these localities besides the ordinary large naturalists' dredge (see fig. 7), tow-nets were used, and also Mr. A. O. Walker's small dredge with a canvas bag for bringing up samples of the bottom, to be washed and sifted for small Crustacea, &c. Dr. Chaster reports to me that of the

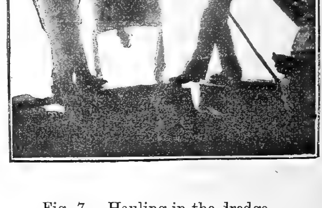


Fig. 7. Hauling in the dredge.

three species of Foraminifera new to the district obtained, along with many other species, from the mud at 60 fms., one, *Lagena hertwigiana*, is new to British seas.

The Zoophytes from these various hauls have been examined by Miss L. R. Thornely, who reports 38 species in all, including the following seven which are new to the district :—*Campanularia raridentata, Lafoëa fruticosa, Calycella fastigiata, Cuspidella grandis, C. costata, Halecium muricatum* and *Sertularella tenella.* The Polyzoa collected during this day represent 57 species, from which Miss Thornely reports three, *Hippothoa flagellum, Membranipora trifolium* and *Schizoporella simplex*, as being new to our district, and two, *Schizoporella linearis* and *Stomatopora granulata*, new to the Isle of Man lists.

On the following day (June 6th) on the way back to Liverpool dredging from the 'Mallard,' was conducted at the following places :—

1. Twenty miles South East from Port St. Mary, 26 fms. : good productive ground, large haul :—*Suberites domuncula, Spongelia fragilis, Lafoëa pygmæa** and *Plumularia frutescens,** (altogether 25 species of Zoophytes, and 24 species of Polyzoa), *Cucumaria hyndmani, Antedon rosacea, Amphiura chiajii, Clavelina lepadiformis, Corella parallelogramma.*

2. Twenty-five miles South East from Port St. Mary, 23 fms., large haul :—*Cellaria fistulosa, Sertularia operculata, Antedon rosacea, Carinella linearis, Onuphis conchilega, Diastylis biplicata, Forbesella tessellata, Cynthia echinata.*

3. Twenty miles North West from Liverpool bar, 18 fms., poor haul.

4. Fifteen miles North West from the bar, 16 fms., poor haul.

On all these occasions besides the surface tow-nets, a bottom tow-net was attached a little way in front of the dredge, and appeared to work well; its contents were usually a good deal different from those of the surface nets.

Miss Thornely reports that the Zoophytes collected on June 6th, represent 25 species of which, one, *Plumularia frutescens*, is new to the district; while the Polyzoa represent 24 species. The detailed lists of all these collections are kept for future use, in connection with the reports on special groups, and at least one specimen of each species, is now being labelled and deposited in the "Local" Collection in the Zoological department of University College, Liverpool.

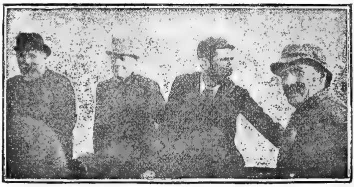


Fig. 8. A Dredging Party.
(J.V., T.C., W.A.H., W.J.S.)

After the formal Opening, work was carried on steadily at the Biological Station during the remainder of the summer till the end of September. Members of the Committee visited the station from time to time, and students of Science from London, Cambridge, Manchester, Liverpool, Aberystwyth and Edinburgh, were at work for longer or shorter periods. Mr. W. J. Waterhouse, B.Sc., acted as temporary curator for a short period; but it is the intention of the Committee, if they can obtain the services of a suitable young scientific man, to appoint early next spring, a resident Curator of the Station, who

will in the absence of Members represent the Committee, will carry on observational and experimental work under the Director, collect and preserve specimens for the investigations of the specialists, and for the supply of laboratories and museums, and, so far as possible, help any of the workers, who require it, in collecting material and in their investigations. The Committee are aware that this appointment will be a considerable drain upon their slender resources, but they are convinced that the presence of a resident curator would be of such advantage to those working at the Station, that they feel it is their duty to make an effort to supply the necessary salary.

Fig. 9. A good Collecting Ground at low tide.

STATION RECORD.

During the half-year, from the opening of the Station in June to the present month, the following naturalists have worked at the laboratory :—

DATE.	NAME.	WORK.
1892.		
June.	Mr. I. C. Thompson, F.L.S., Liverpool ...	Copepoda.
—	Mr. A. O. Walker, F.L.S., Colwyn Bay ..	Amphipoda.
—	Sir James Poole, Liverpool	General.
—	Mr. A. Leicester, Southport	Mollusca.
—	Mr. J. Vicars, Bootle, ...	General.
—	Prof. W. A. Herdman, F.R.S., U.C.L'pool...	Tunicata.
—	Mr. R. J. Harvey Gibson, F.L.S., U.C.L. ...	Algæ.
—	Dr. R. Hanitsch, Univ. Coll., Liverpool ...	Sponges.
—	Prof. E. F. Weiss, Owens Coll., M'chester ...	Algæ, &c.

—	Prof. Denny, Firth College, Sheffield	General.
—	Mr. Arnold T. Watson, Sheffield	Annelids.
—	Mr. R. L. Ascroft, Lytham	General.
	[A number of others forming the dredging party on the "Mallard" expedition of June 4th to 6th paid a passing visit to the Station.]	
—	Mr. W. J. Beaumont, Cambridge	Cœlenterata, &c.
—	Mr. W. J. Halls, Liverpool	Hydroida.
—	Mr. H. C. Chadwick, Manchester	Echinodermata.
—	Mr. I. C. Thompson, Liverpool	Copepoda.
—	Prof. W. A. Herdman, Univ. Coll., L'pool ...	Tunicata.
July.	Mr. W. J. Waterhouse, B.Sc., U.C.L'pool ...	General.
—	Mr. F. W. Gamble, B.Sc., O.C.M'chester ...	Turbellaria.
—	Mr. J. H. Salter, B.Sc., U.C., Aberystwyth ...	General.
—	Mr. W. J. Beaumont, Cambridge	Cœlenterata, &c.
—	Mr. J. Lomas, Liverpool...	Polyzoa.
—	Mr. Edw. T. Browne, B.A., U.C., London...	"Plankton."
—	Mr. W. H. Heathcote, Preston	Mollusca.
—	Mr. H. Sykes, Preston	Mollusca.
August.	Mr. B. Lal Chaudhuri, B.A., U. of Edin. ...	General.
—	Mr. W. J. Waterhouse, B.Sc., U.C., L'pool	General.
—	Mr. Rowe, Univ. Coll., Liverpool...	General.
—	Mr. J. A. Clubb, Univ. Coll., Liverpool ...	Nudibranchiata.
—	Dr. Ellis, Liverpool	General.
—	Mr. I. C. Thompson, F.L.S., Liverpool ...	Copepoda.
—	Mr. Edw. T. Browne, B.A., U.C., London...	General.
—	Mr. W. J. Beaumont, Cambridge	Cœlenterata, &c.
—	Mr. Rich. Assheton, Owens Coll., M'chester	Tow-nettings, Gnl.
September.	Mr. W. J. Halls, Liverpool	Hydroida.
—	Mr. Chopin, Manchester...	General.
—	Mr. W. J. Beaumont, Cambridge...	General.
—	Mr. B. L. Chaudhuri, Univ. of Edinburgh...	General.
—	Mr. Geo. Brook, F.L.S., Univ. of Edinburgh	General.
—	Mr. I. C. Thompson, Liverpool	Copepoda.
—	Prof. Herdman, Univ. Coll. Liverpool... ...	Tunicata.
—	Mr. A. O. Walker, Colwyn Bay	Amphipoda.
—	Mr. J. A. Clubb, Univ. Coll. Liverpool ...	Nudibranchiata.
—	Mr. P. M. C. Kermode, Ramsey	General.
October.	Mr. F. W. Gamble, Owens Coll. M'chester...	Turbellaria.
November.	Mr. I. C. Thompson, Liverpool	Copepoda.
—	Mr. P. F. J. Corbin, Univ. Coll. Liverpool...	Fishes.
—	Prof. W. A. Herdman, Univ. Coll., L'pool ...	Tunicata.

This excellent list of those who have made use of the Station, and the fact that during the greater part of the summer the laboratory has been continuously occupied by workers, sufficiently justify the action of the Committee in moving the institution to such a favourable spot as Port Erin.

THE PUFFIN ISLAND STATION.

In relinquishing the Puffin Island establishment, we are glad to think that it will be still kept up as a Biological Station. Dr. Philip White, and Prof. Reginald Phillips, and others connected with the University College of North Wales, at Bangor, have formed a Local Committee for the purpose of taking over our effects, and continuing our work; so we may congratulate ourselves that in moving to Port Erin, we have not only bettered our own position and established a new Biological Station, but we have also indirectly been the means of starting the Bangor Committee on similar work, and so have practically added one to the local centres of marine investigation.

Fig. 10. W.A.H. and R.H. on the rocks at Puffin Island.

NOTES ON WORK DONE AT PORT ERIN.

Mr. F. W. Gamble, B.Sc., Berkeley Fellow (in Zoology) of the Owens College, Manchester, worked at the laboratory during most of July, and also for a week at the beginning of October. He commenced there a systematic study of the Turbellarian Worms, collecting, preserving,

and identifying the specimens. He succeeded in finding 23 marine species and 2 fresh water forms: with one exception (*Leptoplana tremellaris*) all these are new records for the district, the Turbellaria being a group which has not hitherto received adequate attention in our seas.

Mr. Gamble informs me that the most noteworthy forms in his list are:—*Stylostomum variabile*, *Cryptocelides loveni*, *Promesostoma lenticulatum* and *Plagiostoma sulphureum;* with the exception of *Stylostomum variabile*, these are all new to the British Fauna. Mr. Gamble's detailed report upon the Turbellaria of the L. M. B. C. district—which will be one of the first-fruits in the way of published scientific work from the new station—is now nearly finished. It will be laid before the Biological Society at the next meeting, and will be published in the forthcoming volume of Transactions.

Mr. W. J. Beaumont stayed for nearly four months at the Station, and besides working through a series of type animals of various invertebrate groups, he kept a number of live animals under observation, and verified for his own satisfaction points that had already been determined. In this way he reared and watched stage by stage the developing young of the small star-fish *Asterina gibbosa* which is very abundant in the "Coralline" pools at Port Erin; and at my suggestion he kept under observation for a long period living colonies of the Alcyonarian *Sarcodictyon catenata*, which is dredged not far outside the breakwater. The polypes of *Sarcodictyon* are very shy or sensitive, and have very rarely been seen in the expanded state. From Mr. Beaumont's observations there can be no doubt that it is the bright day-light that affects them. He found by visiting the laboratory at night that they were then frequently fully expanded, and also occasionally on dull mornings. Mr. Beaumont also made some observa-

tions on Lucernarians, which will form the subject of a short paper by himself, to be laid before the Biological Society at an early meeting. Mr. Beaumont reports to me that he collected two species of Lucernarians under stones on the shore, between the boat jetty and the breakwater on the south side of Port Erin harbour. The one species was *Lucernaria quadricornis*, Müller; the other he identifies as *Depastrum cyathiforme*, Sars, and of this two varieties, a light reddish brown and a dark purple, occur—both being adult.

Fig 11. The Laminarian Zone at low tide. Good Collecting Ground.

Mr. E. T. Browne, B.A., was at the Station for some weeks in July and August, and spent most of his time in studying the "plankton" or surface life. Amongst the animals he collected and identified were the following which had not been previously recorded:—*Tiara pileata* (= *Oceania episcopalis*, Forb.), *Aglaophenia tubulifera*, with Corbulæ, and *Anceus maxillaris* (found before but not recorded), male and female with eggs, inside *Sycandra compressa* on the rocks near the laboratory.

Mr. Chadwick was occupied in collecting and preserving material for his work upon the minute structure of Starfishes, which will form the subject of a paper to be read before the Biological Society in spring.

The faunistic work of other investigators, and of some members of the Committee who were at the station, will be found referred to further on; while a few of the workers such as Mr. Chaudhuri, being students who were making

use of the laboratory for their own purposes which did not include the prosecution of research, have of necessity left no record requiring publication.

Amongst some of the other noteworthy forms found at Port Erin or in the neighbourhood by workers at the station during the summer may be noted :—Foraminifera, *Astrorhiza limicola*, dredged off Port Erin, *Haliphysema tumanowiczii*, off Port St. Mary. The interesting Tubicolous Infusorian *Folliculina ampulla* is abundant in pools close to the Biological Station. Two species of Lucernarians are not uncommon, near breakwater on the south side of Port Erin bay; also *Adamsia palliata* with *Pagurus prideauxii*, and many other anemones. *Convoluta*, and various other Turbellaria, are found in shore pools close to the laboratory, and amongst sea-weeds in other parts of the bay, while various rarer forms have been dredged by Mr. Gamble, further out, *e.g.* off Bradda Head, and in Bay Fine. *Cephalothrix bioculata* is in the Coralline pools, and *Dinophilus tæniatus*, while a species of *Spadella* is found round the shore. *Antedon rosaceus*, the rosy feather star, is dredged close to Port Erin, it is usually infested with *Myzostomum*. Mr. Beaumont obtained 20 specimens of *Myzostomum* from one *Antedon*. *Porania pulvillus* and *Palmipes membranaceus* are not uncommon in the deeper water off Port Erin, and *Ocnus brunneus* has been taken. *Pleurobranchus membranaceus* is found in shore pools at Poolvaash near Port St. Mary. *Aplysia punctata* is common outside the breakwater and in Bay Fine, and also the interesting Ascidian *Corella parallelogramma*. *Doto pinnatifida* (two specimens on *Antennularia*, dredged Sept. 14th,) *Triopa claviger*, *Goniodoris castanea*, *Limapontia nigra*, *Runcina coronata*, and *Actæonia corrugata*, were all obtained; and also the following other Mollusca, *Pandora inæquivalvis*, *Lima*

loscombii, *Capulus hungaricus*, *Scaphander lignarius*, *Otina otis*, *Bulla hydatis*, and *Melampus bidentatus*, mostly from Bay Fine.

Molgula citrina and *Ascidia depressa* are under stones near Port St. Mary, and many species of compound Ascidians, especially Botryllids, such as *Botryllus morio*, *B. aurolineatus*, *B. violaceus*, and *Botrylloides albicans*, are common both at Port Erin and Port St. Mary.

Protective Colouring.

The common shore prawn, *Virbius varians*, found at Port Erin, and probably all round the coast, is a most marked case of protective colouring. Specimens taken from a "zostera prairie" are of the same bright green colour as the "Sea grass," to the blades of which they adhere closely, (see Pl. VI. fig. 3). Their eggs also are green. Specimens, however, which are found amongst the red sea-weeds, such as half rotten masses of *Delesseria* and *Rhodymenia* (see fig. 2), are either completely red, or red with a slight mottling of white or grey. Specimens found on a sandy bottom, or on small gravel, are mottled black, grey and white. These are all cases of simple, but very complete, protective colouration.

The specimens of *Virbius*, however, which occur upon the dark brown sea-weed *Halidrys siliquosa* present a more complicated case, as they actually mimic the chambered capsules of the Alga, both in form and colour, and also in position. The Crustacean is here of a dark brown colour, and has the habit of clinging to the stem in such a position that the body extends straight outwards in a stiff attitude (see Pl. VI. fig. 1); and the plant may be shaken to some extent without affecting the pose of the Crustacean, and its resemblance to the capsules.

These are clear cases of the Crustaceans having become

adapted to suit their surroundings through the action of natural selection, but there seem to be the four following alternatives as to the present position of affairs :—

1. There may be the 4 above noted (and possibly others) colours of individuals as 4 distinct varieties, which produce young of their own colours, keep to their own special habitat, and do not inter-breed. This I think unlikely.

2. There may be no permanent varieties, but the young when they first settle down upon the sand or sea-weeds may, whatever their colour may be, have great adaptability, so that under the influence of their environment they soon assume a protective colouration. This would be a case of "direct action of the environment," partly perhaps due to food.

3. This adaptability—or marked susceptibility to the influence of environment—may possibly be retained throughout adult life, so that conceivably a green *Virbius* might migrate from the *Zostera* bed to a clump of *Halidrys*, and then change from a green to a dark brown colour.

4. Lastly, the young of all 4 colours may present great variation in tint, and then under the action of natural selection those which are not specially fitted to their surroundings in each case will be eliminated.

I am inclined myself to regard the last as the most probable explanation, but we have arranged to start some experiments and observational broods at the Biological Station which it may be hoped will throw some light upon these and other similar cases.

Other Faunistic Work.

Looking at the additions to the "Fauna" during the year:—Mr. A. O. Walker records amongst Amphipoda, in addition to those noted above, *Harpinia neglecta*, Sars, (noted before as *H. plumosa*), Colwyn Bay and Port Erin,

Dexamine thea, Boeck, from Port Erin harbour (common), *Hoplonyx similis*, Sars (new to Britain), *Megamphopus cornutus*, Norman, and a new species of *Podocerus*, from Laxey Bay, for which the following name and diagnosis are proposed by Mr. Walker :—

"*Podocerus herdmani*, n. sp.

"Allied to *P. falcatus* and *P. minutus*, G. O. Sars, but differing in the 'hand' of the second gnathopod of the male, as shown in annexed figures 12 and 13.

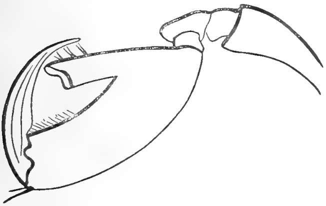


Fig. 12. *Podocerus minutus* (after G. O. Sars.)

Fig. 13. *Podocerus herdmani*, n. sp.

The large tooth which in these species springs from the base of the hind margin, in this species is much shorter and rises from nearly the centre. There is also a prominent tooth near the centre of the hind margin of the 'finger' which is very characteristic. The female resembles *P. minutus*. Length 3 mm."

In regard to *Megamphopus cornutus*, Mr. Walker reports to me "Canon A. M. Norman, *in lit.* Dec. 6/92 gives *Protomedeia longimana*, Boeck 1870, and *Podoceropsis intermedia*, Stebbing 1878, as synonyms of *Megamphopus cornutus*, Norman, 1868. At the same time he sent me his type specimen, also one from Farland Point, Cumbrae, and one from G. O. Sars labelled *Protomedeia longimana* from the Lofoten Islands. Of these the last has the 'horn' on the 1st epimere by far the longest as it reaches to the end of the 3rd (apparent 1st) joint of the lower

antenna. Next comes the type from the Shetlands in which it barely reaches the proximal end of that joint. In the Cumbrae specimen—also a male, but not so large as the others—it cannot be seen at all, nor can it in my specimens (still smaller) from the Isle of Man. The second gnathopod is also much more highly developed in length, spines on palm of hand &c., in the Lofoten and Shetland specimens than the others. It is probable that the above differences may be only a question of age, but it is not impossible that the latitude may have an influence in reducing the size and development of the species. Upon a comparison of my specimens of *Podoceropsis sophiæ*, Boeck and *P. intermedia* Mr. Stebbing agrees with me that the two species are obviously distinct."

Fig. 14. A.O.W. washing sand for Amphipods.

Immediately after the publication of Mr. Walker's "Revised Report upon the Podophthalmata" in July, 1892, several additional species were found, so an "Addenda" slip has now been printed and issued to all purchasers of Vol. III. of the "Fauna." This slip contains records of the following species:—*Inachus dorynchus*, *Stenorhynchus longirostris*, *Ebalia cranchii*, *Pinnotheres veterum*, *Pirimela denticulata*, *Spiropagurus hyndmanni* and *Nephrops norvegicus*. Since then in dredging from Bradda Head to the Port Erin breakwater, in November, we got a Schizopod (*Gastrosaccus sanctus*) new to the district, the only former British locality being Jersey, and a *Microdeutopus* which is probably new.

Mr. A. Leicester who took charge of the Mollusca during our expeditions, and has also worked through a good

deal of material which he had collected at Puffin Island last year, reports to me that he has fifteen species of Lamellibranchs and Gastropods to add to our records: of these 8 are from Bay Fine and the immediate neighbourhood of Port Erin, and 7 from Puffin Island. Among the more noteworthy of these, collected and identified by Mr. Leicester and Dr. Chaster of Southport, are *Solecurtus antiquatus*, *Bulla utriculus*, *Cyclostrema cutlerianum*, and *C. nitens*, *Odostomia warreni* and *Defrancia teres* from off Port Erin; and *Mya binghami*, *Homalogyra rota*, *Odostomia nivosa*, and *O. turrita* from Puffin Island. Mr. W. H. Heathcote, of Preston, who spent some time at the Biological Station in July, was chiefly engaged in dredging for Mollusca about Bay Fine (see Pl. I.). He succeeded in getting a number of the rarer forms amongst which may be recorded *Defrancia leufroyi*, and *Fusus antiquus*, var. *despectus*. Mr. Heathcote also reports to me *Utriculus hyalinus*, Turt., cast up at Southport, new to the district.

During September Mr. A. Chopin, of Manchester, carried on some dredging from Port St. Mary and Port Erin, and was able to add at least two species new to our records, viz. the sponge *Reniera rosea*, Bowerb. (from Fleswick Bay and Perwick Bay), and the crab *Pirimela denticulata*, Leach, (off Spanish Head, 15 fms.). *Reniera rosea* was recorded by Bowerbank from Tenby and Sark. Dr. Hanitsch informs me that this species seems to have a larger amount of "spongin" than most other Renierid sponges, and approaches therefore the Chalinidæ. The only other sponge new to the district reported by Dr. Hanitsch is the Desmacidonid *Halichondria* (*Amphilectus*) *expansa*, B., dredged on September 24th off Clay Head. It had previously been obtained only at Skye, by Dr. A. M. Norman. The specimens of *Spongelia fragilis* which

we dredged off Clay Head and Garwick are noteworthy for being the largest yet found in our district.

Mr. I. C. Thompson has been engaged for some time on a "Revision" of the L. M. B. C. Copepoda, which will incorporate the work of his previous reports with all the recent "finds" in this group—"finds" which during this last season have been astonishing in their number and quality. I have suggested to Mr. Thompson to give in this 'Revision,' (which will be laid shortly before a meeting of the Biological Society) a simple outline figure, with details of the diagnostic points, of every species of L. M. B. C. Copepoda, an addition which while entailing a great deal of extra labour on the author, will I am sure increase greatly the usefulness and value of his paper.

Fig. 15 I.C.T. picking out Copepoda.

Mr. Thompson reports to me as follows :—"Over 20 species of Copepoda new to the district have been added to our record during the last year, viz.—*Mesophria pallida*, *Euchæta prestandræ*, *Cyclopina magna* (n.sp.), *Ectinosoma curticorne*, *Notopterophorus papilio*, *Laophonte horrida*, *Laophonte spinosa* (n.sp.), *Normanella dubia*, *Dactylopus tenuiremis*, *D. flavus*, and *D. minutus*, *Thalestris rufo-violescens*, *T. peltata*, *Porcellidium tenuicauda*, *Anchorella uncinata*, *Ameira attenuata* (n.sp.), *Stenhelia denticulata* (n.sp.), *Monstrilla rigida*, *Lichomolgus agilis*, *Cylindropsyllus lævis*, *Tetragoniceps bradyi*, and *Paramesochra dubia;* six of these, viz., *Euchæta prestandræ*, *Monstrilla rigida*, *Cyclopina magna*, *Ameira attenuata*, *Stenhelia denticulata*, and *Laophonte*

spinosa, are additions to the British Fauna, and the four last are new to science. The chief causes for so large an addition to our Copepodan fauna are, first the more special attention we now pay to the minute examination of mud and other dredged materials, which have yielded the majority of the above-named species—Port Erin bay and particularly the muddy bottom just inside the breakwater having proved to be specially rich ground ; and, secondly, the establishment of Professor Herdman's "Fishery Laboratory" at University College, where large numbers of fish are constantly being examined, and, where under the keen scrutiny of Mr. Corbin a large number of fish parasites have been found in situ on the gills of the fishes. Many of these yet await examination, and there is evidently still much to be achieved by a careful examination of the mouths and gills of our common fishes. The branchial sacs of Ascidians collected by Prof. Herdman, have yielded many kinds of parasitic Copepoda, one of these, *Notopterophorus papilio*, a remarkably interesting animal, being new to the district."

A new Copepod, *Lichomolgus agilis*, has been very recently found and described by Mr. T. Scott, of the Scottish Fishery Board, as frequenting Cockle shells. This Copepod we have also found here, in all the cockles examined, and it is probably a common form which has been hitherto overlooked on account of its peculiar habitat.

The Hydroid Zoophytes and Polyzoa collected during the year have, as in previous seasons, been examined by Miss L. R. Thornely, with whom I have gone over a good deal of the material, including any doubtful or difficult specimens. One of the most interesting points is that Miss Thornely has been able to establish that the *Lafoea pygmæa*, Ald., of Hinck's "Zoophytes" is really, as Alder seems to have indicated in his drawings, a species of

Calycella. It has in our specimens from rock pools at Port Erin, obtained on Sept. 25th., a distinct operculum, and the name of the species must consequently become *Calycella pygmœa.* In these same pools the following other Zoophytes have been found lately:—*Clava multicornis, Coryne van-benedeni, Campanularia fragilis,* Opercularella lacerata, Sertularia operculata, Plumularia similis;* and 9 species of Polyzoa.

On November 13th., a dredging off Bradda Head yielded 11 species of Zoophytes, and 7 species of Polyzoa, none very specially rare. It ought, perhaps, to be stated that all these lists of collections of Zoophytes and Polyzoa from various localities now being determined by Miss Thornely, are kept for record in the MS. tables of geographical distribution within our district, which will be published in some future report, when they seem sufficiently complete. A number of Zoophytes, Polyzoa, and other invertebrata have been sent to the Laboratory lately by Captain Eccles and the other bailiffs in connection with the investigations now going on into the food, &c., of fishes. One such gathering dredged from near Eastham, in October, contained 21 species of Zoophytes and 11 of Polyzoa. One of the Zoophytes was *Bougainvillea ramosa,* which had not previously been reported from our district. Another gathering, from the Rock Channel, contained 18 species of Zoophytes and 15 of Polyzoa. A third set, trawled in Morecambe Bay, consisted of 9 species of Zoophytes and 3 of Polyzoa, amongst which were *Eudendrium annulatum,* and *Bowerbankia caudata.*

British Association Committee.

At the British Association meeting in Edinburgh, early in August, a committee was formed, with a small grant, for the purpose of exploring further the southern part of the

Irish Sea. "This committee consists of Professor Haddon, Mr. W. E. Hoyle, Mr. Geo. Brook, Mr. A. O. Walker, Mr. I. C. Thompson (Secretary) and Professor Herdman (Chairman)," and the grant will be expended in providing a series of short dredging expeditions to the more unknown parts of the area. The first of these British Association Committee expeditions was organized at the end of September when the steam trawler "Lady Loch" of Douglas was hired for September 24th. The wind was so strong and the sea so heavy that it was quite impossible to do any work off the southern and western sides of the island, so we steamed up the eastern side and spent the day in dredging in the neighbourhood of Laxey at the following localities:

Fig. 16. Emptying the dredge on deck.

1. Off Clay Head, 20 fms., several hauls; varied bottom. *Polymastia robusta*, *Suberites domuncula*, *Amphilectus incrustans*, *Spongelia fragilis* (large specimens), and a

Desmacidonid sponge (the *Halichondria expansa* of Bowerbank) which is new to the district, and probably belongs to the genus *Amphilectus*, ten species of Zoophytes and fourteen species of Polyzoa, *Pinnotheres veterum*, *Lima hians*, *Psammobia tellinella*, *Ascidia mentula*, *&c.*

2. Off Garwick Head, 4—12 fms., "Melobesia" bottom. Several hauls. *Aglaophenia pluma* and seven other species of Zoophytes, *Amathia lendigera*, *Ebalia cranchii*, *Podocerus herdmani*, n. sp.

3. Laxey Bay, 8 fms., "Zostera" bed.

Campanularia angulata, *Clytia johnstoni*, *Antennularia antennina* and *Sertularia polyzonias*, *Cerapus difformis*, *Membranipora spinifera** and six other species of Polyzoa, Compound Ascidians, *Pectunculus glycimeris* (large, alive).

The Ascidians dredged in this expedition yielded a number of parasitic Copepoda amongst which were *Botachus cylindratus*, *Notopterophorus papilio*, *Doropygus pulex* and *D. poricauda*, *Notodelphis allmani* and *Ascidicola rosea*.

On this occasion a specimen of the somewhat uncommon fish Müller's Top-knot (*Zeugopterus punctatus*) was obtained at Port Erin. It had been caught by a net close to the shore, and was kindly brought to the laboratory by Mr. John Costain.

PUBLICATIONS, &c.

Since the last annual report, the third volume of "the Fauna of Liverpool Bay" has been published (July, 1892). It contains papers on the marine Algæ, Porifera, Annelids, Crustacea, Mollusca, Tunicata, and other groups, and is illustrated by twenty-three plates and a chart. As is stated in the introduction to the volume, the additional species recorded in the various papers now brings the number of marine animals and plants known

to inhabit the L.M.B.C. district up to 1685. To this has still to be added the 105 new forms found during this last summer and referred to in the present report.

A melancholy interest attaches to one of the papers in Vol. III. of "The Fauna," viz., The Report upon the Testaceous Mollusca. It was the last piece of work of the late Mr. F. Archer who was a member of the Committee from the beginning, and has always taken an active interest in the work. In addition to all more personal feeling of loss, his ready sympathy, kindly criticism, and sturdy common sense will be greatly missed at the Biological meetings and on the collecting expeditions. Mr. Archer's place on the committee has been filled up by the election, on June 3rd, of Mr. John Vicars. With Surgeon-Colonel S. Archer's sanction I took charge of his brother's note books for the purpose of having his work on the Mollusca published. Fortunately Mr. Brockton Tomlin of Chester was kind enough to undertake the responsible work of putting the notes and records in proper form for the printer. It is a matter of great satisfaction to the Committee that one so eminently qualified both as a conchologist and also from his knowledge of Mr. F. Archer's collections and notes and methods was found willing to undertake this work and carry it out without delay.

The Mollusca of the future L.M.B.C. expeditions will be worked up and reported upon by Mr. Alfred Leicester, Priory Gardens, Birkdale, who will gladly receive and acknowledge records of specimens from other conchologists in the district.

We have suffered another loss in the death, quite recently, of Mr. T. J. Moore the last President of the Biological Society. Mr. Moore's poor health for the last few years has prevented him from taking any active part

in our expeditions, but he attended as far as possible the meetings, and we have always had his sympathy and advice in our investigations. Unfortunately his long expected report upon our local marine fishes was never completed. In the first two volumes of the "Fauna" we have two papers from his pen, one on the American Clam (*Venus mercenaria*) in Vol. I., and a report upon the L.M.B.C. Seals and Cetaceans in Vol. II.

It is proposed that the vacancy caused by Mr. Moore's death should be filled up by the election of His Excellency Spencer Walpole, LL.D., Lieutenant-Governor of the Isle of Man, who has kindly consented to serve on the Committee.

It is an encouraging and hopeful feature of our first season's work at Port Erin to notice the number of new recruits who are joining our School of Marine Biology. In addition to those noted above as having done some special work at the biological station, Dr. G. W. Chaster, of Southport, is helping Mr. Leicester with Mollusca and is also working at the Foraminifera of the district, and Mr. P. J. F. Corbin is collecting records and specimens of the fishes and is paying special attention to their parasites. The Committee hope that not only may they continue to draw together the young biologists of Liverpool and the neighbourhood, but that Manxmen interested in Natural History may now be induced to work as students at the Port Erin laboratory, and so fit themselves for investigating seriously the abundant marine fauna and flora of their Island.

All faunistic work—the distribution and relations of species, their variations, their habits, and "habitats," the nature of their distinguishing characteristics and the bearing of these upon the natural surroundings and mode of life—all these, always matters of great interest to those

who appreciate nature, have now become of special importance in the philosophy of Biology since Darwin showed how much centres around the problem of the "Origin of Species." Now that we are beginning to understand how little a species or variety is, and yet at the same time how much of world-wide importance the differentiation of these sets of individuals implies, the work of the "field naturalist"—if inspired by the true scientific spirit and regulated by due caution—acquires a new meaning and a real value. The Biologist cannot afford to despise any line of enquiry. All accurate observations have their use, and may at any time prove of great importance by illustrating some theoretical question and taking their place in the elucidation of the system of nature which we see around us and of which we form a part.

In conclusion I may state that the Committee are now trying in various ways to add to the facilities for work at the Biological Station in view of the coming Spring and Summer. A few useful books of reference and monographs on British animals are being collected to form a small working library, extra dredges, tow-nets, and other collecting apparatus, small aquaria and vessels, and supplies of various kinds, are now being laid in, so that the conditions for work in the laboratory may be reasonably expected to be much more favourable in the future than they were last summer. Then it may be pointed out—perhaps after our association with Puffin Island it is necessary to emphasize this—that at Port Erin there is the comfortable Bellevue Hotel, and other hotels, and lodgings of all kinds, at which students can live; and finally the Biological Station is open to lady-students as well as to men, and the neighbourhood is one which, taken along with the presence of the laboratory, and dredging

facilities, offers many advantages to, and would probably supply the diverse wants of, parties of students or vacation expeditions of scientific Societies.

In view of the books of reference and the apparatus we are now buying, and of the further additions to the stock which are contemplated, as well as the maintenance of a permanent Curator, our Hon. Treasurer asks me to state that our expenses in the coming year will probably be considerably heavier than they have been in the past, and that he trusts that there will be some substantial additions to the subscription list.

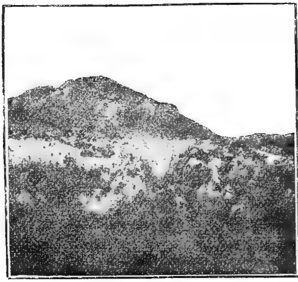


Fig. 17. Rocks showing white band caused by myriads of adhering *Balanus*.

I append to this report:—(A.) the Regulations drawn up by the Committee in regard to the Station, and with which they expect workers to comply, and (B.) the Hon. Treasurer's Balance Sheet and list of Subscribers.

LIST OF THE PLATES.

Plate I. The southern end of the Isle of Man, showing Port Erin and the neighbourhood.
Plate II. Plan of Port Erin Bay, with depths.
Plate III. View of the Biological Station.
Plate IV. Plan of the Biological Station.
Plate V. Plan of a large shore pool at Port Erin.
Plate VI. *Virbius varians* protectively coloured on different surroundings.

Appendix A.

LIVERPOOL MARINE BIOLOGICAL STATION AT PORT ERIN.

Regulations.

I.—This Biological Station is under the control of the Liverpool Marine Biology Committee, the executive of which consists of the Hon. Director, Prof. Herdman, and the Hon. Sec. and Treas., Mr. I. C. Thompson.

II.—In the absence of the Director, and of all other Members of the Committee, the station is under the temporary control of the Curator, who will keep the keys, and will decide, in the event of any difficulty, which tables are to be occupied by particular workers, and how the boats, and dredges, microscopes, &c., are to be employed.

III.—The Curator will be ready at all reasonable hours, and within reasonable limits, to assist workers at the station, and to do his best to provide them with material for their investigations.

IV.—Visitors will, on application to any Member of the L. M. B. C., or to the Curator, be admitted at reasonable hours to see the station, so long as it is found not to interfere with the Scientific Work.

V.—Those who are entitled to work in the station, when there is room, and after formal application to the Director, are :—(1) Annual Subscribers of one guinea or upwards to the funds (each guinea subscribed entitling to the use of a table for four weeks), and (2) others who pay the Treasurer 10s. per week for the accommodation and privileges. Workers at the station are recommended to board at the Bellevue Hotel.

VI.—Each worker is entitled to a work-place opposite a window in the Laboratory; and to make use of the microscopes, reagents and other apparatus, and of the boats, dredges, tow-nets, &c., so far as is compatible with the claims of other workers, and of the routine duties of the Curator.

VII.—Each worker will be allowed to use one pint of methylated spirit per week, free. Any further amount required must be paid for. All dishes, jars, bottles, and tubes may be used, but must not be taken away from the Laboratory. If any workers desire to make, preserve, and take away, collections of marine animals and plants, they must make special arrangements with the Director in regard to bottles and spirit.

VIII.—Workers desiring to employ larger sailing boats than those belonging to the station, can do so, at their own expense, by applying to Mr. Clague, of the Bellevue Hotel.

IX.—All workers at the station are expected to lay a a paper on some of their results, or at the least a short report upon their work, before the Biological Society of Liverpool, during the current or the following session.

X.—All Subscriptions, payments and other communications relating to finance, should be sent to the Hon. Treasurer, Mr. I. C. Thompson, F.L.S., 19, Waverley Road, Liverpool. Applications for permission to work at the Station, or for preserved animals, or communications in regard to the scientific work, should be made to Professor Herdman, University College, Liverpool.

Appendix B.

SUBSCRIPTIONS and DONATIONS.

	Subscriptions. £	s.	d.	Donations. £	s.	d.
Archer, Francis, B.A., (the late), 21, Mulgrave street	1	1	0		—	
Banks, Prof. W. Mitchell, 28, Rodney-st.	2	2	0		—	
Barlow, Rev. T. S., Bishop's Court, I. of Man	0	10	6		—	
Beaumont, W. J., Cambridge	2	2	0		—	
Bickersteth, Dr., 2, Rodney-street... ...	2	2	0		—	
Brook, George, British Museum (Nat. Hist.) London	1	1	0		—	
Brown, Prof. J. Campbell, University College, Liverpool	1	1	0		—	
Browne, Edward T., B.A., 14, Uxbridge road, Shepherd's Bush, London ...	1	1	0		—	
Burton, Major, Fryars, Beaumaris... ...	2	2	0		—	
Caine, Nath., 10, Orange-court, Castle-street	1	1	0		—	
Caton, Dr., 31, Rodney-street		—		1	1	0
Chadwick, H. C., 2, Market-place, Chorlton-cum-Hardy, Manchester	0	10	0		—	
Chaudhuri, B., 94, Polwarth Gardens, Edinburgh	1	1	0		—	
Clague, Dr., Castletown, Isle of Man ...	1	1	0		—	
Clague, Thomas, Bellevue Hotel, Port Erin	1	1	0		—	
Comber, Thomas, Leighton, Parkgate ...	1	1	0		—	
Coventry, Joseph, 34, Linnet Lane ...	1	1	0		—	
Craig, Robert, 34, Castle-street	1	1	0		—	
Crellin, John C., J.P., Ballachurry, Andreas, Isle of Man	1	1	0		—	

Davidson, Dr., 2, Gambier-terrace... ...	1	1	0	—
Denny, Prof., Firth College, Sheffield ...	1	1	0	—
Derby, Earl of, Knowsley	5	0	0	—
Drysdale, Dr., (the late), 36A, Rodney-street	1	1	0	—
Dumergue, A. F., 79, Salisbury road, Wavertree	1	1	0	
Gair, H. W., Smithdown-road, Wavertree...	2	2	0	
Gamble, Col. David, C.B., Windlehurst				—
St. Helens	2	0	0	—
Gaskell, Frank, Woolton Wood, ...	1	1	0	—
Gaskell, Holbrook, J.P., Woolton Wood,	1	1	0	—
Gell, James S., High Bailiff of Castletown...	1	1	0	—
Gibson, R. J. Harvey, 41, Sydenham-avenue	1	1	0	—
Gifford, J., Whitehouse terrace, Edinburgh	1	0	0	—
Glynn, Dr., 62, Rodney-street	1	1	0	—
Halls, W. J, 35, Lord-street	1	1	0	—
Henderson, W. G., Liverpool Union Bank	1	1	0	—
Herdman, Prof., University College. L'pool.	2	2	0	—
Holder, Thos., 1, Clarendon-buildings Tithebarn-street	1	1	0	—
Holland, Walter, Mossley Hill-road ...	2	2	0	—
Holt, George, J.P. Sudley, Mossley Hill ...	1	0	0	—
Heathcote, W. H., 54, Frenchwood-street, Preston	0	10	6	—
Howes, Prof. G. B., Royal College of Science, South Kensington, London...	1	1	0	—
Isle of Man Natural History and Antiquarian Society	1	1	0	—
Johnstone, Rev. Geo., M.A., 41, Bentley-rd.	0	5	0	—
Jones, Chas. W., Field House, Wavertree	5	0	0	—
Jones, J. Birdsall, 10, St. George's-crescent	1	1	0	—
Kermode, P. M. C., Hill-side, Ramsey ...	1	1	0	—
Leicester, Alfred, Priory Gardens, Weld-rd., Birkdale	1	1	0	—
Lomas, J., Amery-grove, Birkenhead ...	0	10	6	—
Macfie, Robert, Airds	1	0	0	—

Marshall, Prof. A. Milnes, Owens College Manchester	1	1	0		—	
Meade-King, H. W., Sandfield Park, West Derby	1	0	0		—	
Meade-King, R. R., 4, Oldhall-street ...	0	10	0		—	
Melly, W. R., 90, Chatham-street... ...	1	0	0		—	
Miall, Prof., Yorkshire College, Leeds ...	1	1	0		—	
Monks, F. W., Brooklands, Warrington ...	1	1	0		—	
Muspratt, E. K., Seaforth Hall	5	0	0		—	
Mylchreest, J., White House, Kirk Michael, Isle of Man	1	1	0		—	
Newton, Rev. A. S., Grammar School Ramsey, Isle of Man	1	1	0		—	
Poole, Sir James, Tower Buildings ...	2	2	0		—	
Rathbone, R. R., Glan-y-Menai, Anglesey	2	2	0		—	
Rathbone, S. G., Croxteth-drive, Sefton-park	2	2	0		—	
Rathbone, Mrs. Theo., Backwood, Neston	1	1	0		—	
Rathbone, Miss May, Backwood, Neston ...	1	1	0		—	
Rathbone, W., M.P., Greenbank, Allerton	2	2	0		—	
Roberts, Isaac, F.R.S., Tunbridge-wells ...	1	1	0	2	2	0
Shepheard, T., Kingsley Lodge, Chester ...	1	1	0		—	
Simpson, J. Hope, Annandale, Aigburth-drive	2	2	0		—	
Stevenson, W. A., Ballakreighan, Castletown, Isle of Man	1	1	0		—	
Stevenson, W. B., Balladoole, Castletown, Isle of Man	1	1	0		—	
Stewart, W. J., City Magistrates Office ...	1	1	0		—	
Sykes, W., Preston...	0	10	0		—	
Tate, A. Norman, (the late), 9, Hackin's-hey	1	1	0		—	
Thompson, Isaac C., 19, Waverley-road Sefton-park	2	2	0		—	
Thornely, James, Baycliff, Woolton ...	1	1	0		—	
Thornely, The Misses, Baycliff, Woolton ...	1	0	0		—	
Toll, J. M., 340, Walton Breck-road ...	1	1	0		—	
Tomlin, B., 59, Liverpool-road, Chester ...	0	5	0		—	
Talbot, Rev. T. U., 4, Osborne terrace, Douglas, Isle of Man	1	1	0		—	

Vicars, John, 8, St. Alban's-square, Bootle	2	2	0		—		
Walker, Alfred O., Nant-y-glyn, Colwyn Bay	3	3	0		—		
Walker, Horace, South Lodge, Princes-park	1	1	0		—		
Walpole Spencer, LL.D., His Excellency The Governor, Isle of Man	2	2	0		—		
Walters, Rev. Frank, B.A., King William College, Isle of Man	1	1	0		—		
Wareing, W. R., Charlesbye, Ormskirk ...	1	1	0		—		
Watson, A. T., Tapton-crescent, Sheffield	1	1	0		—		
Weiss, Prof. F. E., Owen's College, Manchester	1	1	0		—		
Westminster, Duke of, Eaton Hall ...	5	0	0		—		
Wigglesworth, Dr., Rainhill...	1	0	0		—		
	119	14	6		3	3	0

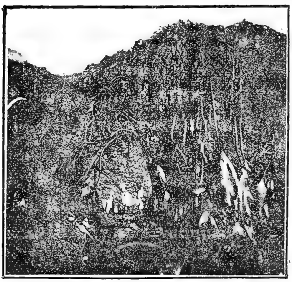


Fig. 18. Rocks covered with seaweeds and animals.

THE LIVERPOOL MARINE BIOLOGY COMMITTEE,

Dr. IN ACCOUNT WITH ISAAC C. THOMPSON, HON. TREASURER **Cr.**

1892	£	s.	d.
To Balance due Treasurer, 1891	3	0	6
,, Expenses of Dredging Expeditions	17	14	6
,, Half-year's Rent of Port Erin Biological Station	5	0	0
,, Microscopes, Apparatus, and Furniture at Port Erin Biological Station	21	4	3
,, Books on Marine Biology	3	5	9
,, Postages, Carriage of Apparatus, &c.	5	12	7
,, Printing and Stationary	26	4	1
,, Sundries	0	11	0
Salary to Temporary Curator	7	0	0
	£89	12	8
By Balance due Treasurer	2	4	8

1892				£	s.	d.
By Subscriptions and Donations	£120	16	6			
Of which £75 11 0 is repaid to Endowment Fund	75	11	0	45	5	6
,, Dividend, British Workman's Public House Co., Ltd., Shares				4	10	0
,, Sale of Reports				17	12	6
,, Sale of Fittings, Boats, &c., at Puffin Island Station				20	0	0
,, Balance due Treasurer				2	4	8
				£89	12	8
Endowment Fund Investment :—						
Brit. Workman's Public House Co.'s Shares				105	11	0
Funds pending Investment				75	0	0
				£180	11	0

ISAAC C. THOMPSON,

HON. TREASURER.

LIVERPOOL, *December* 31*st*, 1892.

Audited and found correct,

ALFRED LEICESTER.

On VARIATIONS in the DORSAL TUBERCLE of *Ascidia virginia*.

By Amy E. Warham, B.Sc.

With Plate VII.

[Read December 9th, 1892.]

In a paper read before the Royal Physical Society in 1881, Professor Herdman, F.R.S., described and figured several varieties of the dorsal tubercle in *Ascidia virginia*, to show the range of its variability. At his suggestion I have lately taken the opportunity of examining nearly 40 individuals of this species with the following results :— There appear to be two simple forms of dorsal tubercle, and several variations from each of these. One of these simple forms is ovate, rounded posteriorly, with the two "horns" straight, and inclined towards each other, but not curved (Plate VII., Nos. 1—5.) The other is almost circular, the two horns curving towards each other, and each horn forming a semicircle. (Nos. 23—26). No. 21 shows an intermediate form.

1. The first variety of the ovate form occurs when one horn curves slightly inwards the other remaining straight (Nos. 6 and 7).
2. Next, both horns curve inwards. (No. 8).
3. One horn may reach more anteriorly than the other. (Nos. 9 and 10).
4. The longer one shows a tendency to turn outwards. (No. 11).
5. The same horn shows a slight, distinct, outward turn (No. 12) which becomes more marked in Nos. 13 and 14.

6. The other horn sometimes becomes longer, (No. 15) and turns outwards, resulting in the form of tubercle seen in No. 19.
7. Or else it gradually curves over in same direction as the first horn (Nos. 16 and 17) which results in the form shown in No. 18.
8. Where both horns turn inwardly, the resulting shape is shown in No. 20.
9. An unusual variety of the ovate tubercle occurs when one horn bends sharply inwards, and then continues its course anteriorly. (No. 22).

1. Returning to the simple, circular form of tubercle, the first variety occurs when one horn curves inwards and turns posteriorly. (No. 27).
2. Both horns may turn slightly inwards. (No. 28). In this specimen the posterior end, to the right of the middle line, was flattened and bore a slight projection on the inner side.
3. Both horns turn in more decidedly and the aperture is very small. (No. 29).
4. Two specimens showed a prolongation anteriorly from the right horn after it had turned up posteriorly. (No. 30, 31).
5. The extreme ends of the horns of the simple circular tubercle sometimes run anteriorly and parallel, with a varying distance between them. (Nos. 32, 33).
6. These parallel ends, then turn outwardly but do not bend posteriorly. (Nos. 34, 35).
7. When these ends curve posteriorly, the result is shown in No. 36. This specimen had a slight projection inwards from the posterior end of the tubercle.
8. Both horns bending in the same direction produce the form shown in No. 37.

Report on the Investigations carried on in 1892 in connection with the Lancashire Sea-Fisheries Laboratory at University College, Liverpool.

By Professor W. A. Herdman, D.Sc., F.R.S.

With Plates VIII.—XI.

[Read March 10th, 1893.]

Introduction.

In December, 1891, I was invited by the Technical Instruction Committee of the Lancashire County Council to submit to them a scheme for the instruction of the Fishermen of the neighbourhood in Biological matters having a bearing upon the fishing industries. In memoranda which I sent to that Committee in Dec., 1891, and Jan., 1892, I pointed out that lectures on the food, reproduction, and life history of food fishes, illustrated by lantern slides, specimens, and microscopic preparations, could be given at different centres; but that of still greater value to the fisheries of the district would be the establishment of a small laboratory in which the investigation of biological problems involved in the fisheries could be carried on by competent observers; and that the results of the work done in this laboratory, and in similar laboratories elsewhere—in fact the additions to our exact knowledge of fishery matters during the year—might be communicated to the Fishermen, under the auspices of the Technical Instruction Committee, in the form of a few lectures annually.

After some further correspondence and the elaboration of details my proposed scheme was adopted, and the first course of lectures was carried on, in the summer of 1892, as arranged by Mr. Bennion, Director of Technical Instruction; while the matter of the laboratory and the

investigations was handed over to be dealt with by the Lancashire Sea-Fisheries Committee.

At a meeting of the Sea-Fisheries Committee held in Preston on February 8th, I submitted a detailed scheme for the establishment and working of a Fisheries Laboratory; and offered to give my services in arranging and supervising the scientific work provided the Committee established the laboratory in connection with the Natural History Department of University College, Liverpool, and found the necessary funds for the salary of an assistant and a small annual grant for apparatus and material. This was agreed to, and a sub-committee, consisting of Mr. W. S. Barrett, Alderman Grindley, and Mr. J. Vicars, was appointed to act along with me in making arrangements as to the laboratory with the Council of University College and to receive estimates for the erection of the building. A form of agreement with the College Council was drawn up and signed, a suitable position was obtained on the roof of the Natural History Department, and a wooden laboratory (20 × 10 ft.), with a small tank-room adjoining (see Pl. VIII.) was erected by the wood-working department of the College, under the direction of Mr. R. Garner, for the sum of £91 4 1. The necessary plumbing, gasfitting and plastering work cost £26 6 6, the tanks £30 10 0, and the other fittings and apparatus, and stock of bottles, spirit, chemicals, &c., up to the end of December, 1892, about £30; while the salary of the assistant, and the current expenses up to the completion of the year will bring the expenses up to the full amount granted, £300.

Along one side of the laboratory under the two larger windows is fixed a strong work-table for the dissection and microscopic examination of specimens, and provided with sink and gas and water fittings. The back of the room is provided with abundance of shelving for the

storage of specimens, while a large cupboard opens out of one corner.

The tank room is provided with five slate and plate-glass tanks, made by Alfred Carter and Co., Liverpool, and arranged as shown in Pl. VIII. They are capable of holding in all 670 gallons, and ought to be very useful in experimental work, or in keeping fishes and other marine animals alive while making observations on their habits; but it can scarcely be hoped that developmental work upon any scale will be possible in such small tanks and where the same water will have to be used over and over again. As yet these tanks have not been made any great use of. So much other work has been going on in the laboratory that the assistant has not had sufficient time in this first season to stock the tanks and get them into working order. But two of them are now being prepared for some contemplated observations on the habits and life history of Shrimps and Cockles.

The laboratory was completed on April 16th, and I then chose as Assistant (with the approval of the Consulting Committee—Alderman Grindley, Mr. Vicars, and Mr. Barrett) young Mr. Andrew Scott of Edinburgh, son of Mr. T. Scott, A.L.S., Naturalist to the Scottish Fishery Board. Mr. Andrew Scott had been a student at Edinburgh University and a junior assistant to Professor Ewart, and more recently had been assisting his father in the work of the Scottish Fishery Board. He commenced work in our laboratory at the beginning of May, but unfortunately had to resign the post at the end of the month in consequence of the serious illness of his father which necessitated the return of the son to Edinburgh to help in carrying on the work there.

I then appointed as Assistant (with the sanction of the Consulting Committee) Mr. P. J. F. Corbin, an advanced

student of the Zoological Department of the Royal College of Science, London, who came with strong recommendations from his teacher Professor G. B. Howes, of South Kensington, and from Professor M'Intosh of St. Andrews, where Mr. Corbin had done some work at the Marine Station in the previous summer. Mr. Corbin started work on June 1st, and is still here, and I hope we may retain his services for a considerable time. This is pre-eminently work where an assistant should become more and more useful, and able to work more rapidly, as time goes on, as in order to render efficient service he has to know as intimately as possible the details of the ground, and the fauna and flora of various parts of the district, all of which takes time to learn. I have much pleasure in testifying to Mr. Corbin's intelligence and energy in his work, and in acknowledging his help in the preparation of this report.

Scope of the Investigations.

In the original scheme of these investigations which I submitted to the Sea Fisheries Committee on January 16th. I indicated some of the more pressing subjects requiring investigation, as follows :—

(1.) Information in regard to the life-history, the growth, the reproduction, and especially the food of the Sole (*Solea vulgaris*) in this neighbourhood; and also the life-history, and food at all stages, of allied fishes of similar habits which are found associated with the Sole, in order to determine to what extent these or other less valuable fishes compete with the Sole for the same food, and so injure it in the struggle for existence.

(2.) The food, habits, enemies, life-history and growth of the Shrimp (*Crangon vulgaris*); the possibility of restricting the Shrimp fishery either in space or time on

account of the injury done to young flat-fish; and the practicability of artificial Shrimp culture in enclosed areas.

(3.) Various questions in connection with the Mussel (*Mytilus edulis*) and the Cockle (*Cardium edule*), and the practicability of mussel-culture on various parts of our shores.

Some of these, and various other matters connected with our fisheries, have been taken in hand during the summer and autumn, and a number of statistics and observations (dealing with over three thousand fish) have been recorded, in some cases leading to definite conclusions, in others still requiring further work. The subjects will be dealt with separately below.

The District, and its Physical Conditions.

The district under the control of the Sea-Fisheries Committee, and to which our investigations are naturally restricted, is practically the area known to Naturalists as the L. M. B. C. district, and which has been faunistically investigated for some years back by the Liverpool Marine Biology Committee. It is the south eastern half of the Irish Sea bounding the Lancashire and Cheshire coasts from Haverigg Point southwards to the North Coast of Wales (see Pl. X.), measuring about 50 miles in length and 40 miles in breadth, to the Isle of Man. In no part of the district is the sea of any great depth, as the deep-water depression which connects the Clyde district deep-water area with the ocean by means of St. George's Channel runs at the other (western) side of the Isle of Man. In no part between Lancashire, Cheshire, and the Isle of Man is a greater depth than 28 fms. found, and over the greater part of the area the soundings are from 10 to 20 fms. (see contour lines on Pl. X.). Along the greater part of the coast (including practically all Lancashire and

Cheshire) the shores are sandy, and the in-shore waters are for the most part sandy and shallow, extensive sand banks abounding especially off the estuaries of the Mersey, the Dee, the Ribble, and in Morecambe Bay. Altogether it may be estimated that there is an area of about 800 square miles lying off the coast over which the depth is less than 10 fms., and an area beyond that of about 1000 square miles where the depth is from 10 to 20 fms. These shallow sandy bays, and channels between the banks, are probably of the very greatest importance as the feeding grounds and nurseries of our most valuable food fishes in their post-larval and immature stages; and I would urge that during the coming year an accurate survey should be made of these areas and a determination of their physical conditions and their fauna and flora. There are four important estuaries in the district, that of the Kent and the Leven conjoined at the northern end of Morecambe Bay, that of the Ribble at Preston, the Mersey at Liverpool, and the Dee between Cheshire and Wales at the southern end of the district. Some parts of the shores of these estuaries are already of value as cockle and mussel beds, but probably a great deal more use could be made of them as suitable grounds for edible Mollusca. Mussel culture should be started, Oyster culture might be worth trying in the estuary of the Dee, and Shrimp culture should be experimented on in some sheltered spot where an enclosure could be made of stakes and rough wattling.

The "Fauna" of the District.

The marine fauna and flora of this district, which are matters of the greatest importance in connection with the feeding of fish and edible Mollusca, have been systematically investigated for some years back by the Liverpool Marine Biology Committee. These investigations have

shown that in some parts of our district, generally a considerable distance off shore, the fauna at the bottom is exceedingly abundant. Dredgings from depths of about 20 fms., at 25 miles N. W. of the Bar Light-ship, bring up such masses of Ophiuroids (chiefly *Ophiocoma nigra*, and *Ophiothrix pentaphyllum*), that the dredge net has more than once been choked to the mouth; and this has happened on several successive hauls, showing that this astonishing abundance of life extends over a considerable area. This must be an important feeding ground for Haddocks and Dabs, as we know that Ophiuroids form a large part of the food of these fishes. Then in other parts of the area off-shore, and in some places between the banks the dredge brings up abundance of Lamellibranch Molluscs—such as *Scrobicularia alba, Tellina balthica, Mactra subtruncata*, and especially *Mactra stultorum*; and these we know from our investigations in the laboratory are a very important constituent of the food of Plaice, and to a less degree of the Haddock. Then again at a spot 25 miles N. W. of the Liverpool Bar, depth 21 fms., the dredge has brought up great numbers of the Annelid *Onuphis conchilega*, and this and other Annelids are a favourite food of Soles, Plaice, &c. Amongst Zoophytes, Polyzoa, and Algæ in shallow water we frequently find enormous quantities of Amphipoda and other smaller Crustacea which we know to be the food of young Cod, Whiting, and other valuable fishes.

Another invertebrate which although not itself marketable is indirectly of great economic importance is the gregarious annelid *Sabellaria alveolata* which builds up the loose sand grains into firm masses of adhering tubes known locally by the fishermen as "ross" and "knarrs." These masses form hummocks, reefs or banks which extend for hundreds of yards or it may be even for miles

in some places. The action of this animal is of importance in the first place in forming a protection to the land by binding together the loose sand on the beach and in shallow water beyond it; and secondly the irregular masses and reefs constitute a sheltering place, and serve as points of attachment for many kinds of animals and consequently as a favourite feeding ground for many others. Prawns there is little doubt are specially abundant and large in the neighbourhood of *Sabellaria* banks. They are said to hide in the crevices between the tubes. This may be so, but probably the food they get there is of more importance as an attraction; and I have little doubt that the great masses of *Sabellaria* tubes are an important feeding ground for various kinds of fishes, both in young and adult stages.

Surface Life.

The surface fauna of the sea in our district, as made known by the microscopic examination of the stuff caught in the tow-nets, has been specially investigated during the dredging expeditions of the Liverpool Marine Biology Committee, and is found to vary much both in nature and in amount from time to time and from place to place. Often for weeks together in spring the surface waters seem to contain very little but Diatoms. These however are in great profusion, and form the food of many animals which in their turn are eaten by fishes. Later on the Diatoms give place to swarms of Copepoda, and the larval stages of many invertebrates. Sometimes one particular species of Copepod will form almost the whole of the tow-net gathering in a particular locality. This is sometimes the case with the large forms *Calanus finmarchicus* and *Anomalocera patersonii*. Under such circumstances the very great abundance of the one form of animal is astonishing, the

surface layer of the sea being so thick with them that every bucket or bottle of water drawn at random brings up multitudes. These swarms may be quite local, a few miles away there may be none, or the surface fauna may have quite a different constitution; and moreover they may disappear from a spot very suddenly, moving off to another locality or sinking to a deeper layer of water. In all probability these changes in the surface fauna have a good deal to do with the movements of fish as it is well known that the larger Copepoda are an important article of food to some fishes, and even to some whales.

At other times—frequently in winter—the surface fauna in our district is chiefly composed of the crystalline worm *Sagitta*; and sometimes the sea over large areas is covered with one or more species of the minute Dinoflagellata belonging to the genera *Ceratium* and *Peridinium.* These are known to serve as food for the Sardine off the French coast, as many as twenty millions of *Ceratium tripos* having been calculated as being at once in the stomach of a Sardine; and no doubt they are equally important in connection with our fisheries here.

These various changes in the surface fauna which are indirectly of great economic importance are not matters of chance, but must all be due to a definite sequence of events; and the question is whether these events, *i.e.*, the conditions of the environment both animate and inanimate, are too complex for us to determine, or whether we can ever hope by accurate observations extending over some years to be able to account for, to predict, and even to regulate, the presence or absence in a particular locality of the food, or the food of the food, of fishes at any given time. At any rate the matter is well worth investigating, and I would propose that definite observations of the meteorological conditions and the surface fauna be taken

systematically, and form a regular part of the work of the New Fisheries Steamer (for detailed plan see below, Appendix A.).

Food of Fishes.

In connection with all this the importance is obvious of determining *in our own district* the *usual* food of all of our valuable fishes, and even of other fishes which are not marketable but which are associated with the food-fishes on the same ground and may compete with them for sustenance. We cannot merely take the results obtained in other countries, as the marine fauna differs in different localities. Nor can we draw conclusions from a few cases. We do not wish to know what some individual fish had for a particular meal, but what that kind of fish is in the habit of eating, *i.e.*, what are the most important constituents of its food without which it could not get on.

In the Fisheries Laboratory, during the eight months from May to December we have examined the stomachs of 3266 animals of which 2087 were fishes, the rest being Shrimps, Cockles, &c., which will be dealt with separately. The circumstances of each case are fully recorded upon a printed form, the particulars noted being :—the species of fish, the date, the locality, &c., of capture, the size, sex, condition of reproductive organs, any other note-worthy point, such as parasites, &c., and the contents of the stomach. These forms are all filed for reference, but I shall only give here a digest of them showing the food of each kind of fish examined for each month in different localities, so far as our statistics give that information. The range in size of the fish in each case is also given. In those cases where the food was partially digested and it was only possible to say that it had once been part of an animal "An. tiss.," for animal tissues, is put.

Sole (*Solea vulgaris*).

No.	Size in inches.	Month	Locality.	Food.
7	$4\frac{3}{4}-6\frac{3}{4}$	May	Rock Channel.	Empty.
3	$6-10\frac{1}{2}$	June	Crosby ,,	Nereis, Crangon.
7	$6-16$	July	Horse Channel and Mersey Bar.	Sagartia troglodytes in one.
42	$4-7\frac{3}{4}$	Aug.	Rock Channel, Dee, and Southport.	Crustaceans, Annelids, An. tiss., Scrobicularia, Pectinaria, Crangon.
6	$10\frac{1}{4}-14$	,,	Horse Channel	Nereis, Pectinaria.
2	$6\frac{1}{2}-7\frac{1}{4}$	Sept.	Morecambe.	Nereis, Pectinaria.
12	$2\frac{1}{2}-6\frac{3}{4}$	Oct.	Fleetwood.	An. tiss., Fish, Sand.

Solenette (*Solea lutea*).

16	$2\frac{1}{2}-4\frac{1}{8}$	May	New Brighton.	An. tiss., Sand, Ostracod.
40	$2\frac{3}{4}-3\frac{1}{2}$	July	Ribble, Blackpool.	Copepoda, Cardium edule, Cypris, Eurydice, Mactra, Tellina, Pectinaria, Carcinus and Pandalus.
12	$2\frac{7}{8}-3\frac{7}{8}$	,,	New Brighton, Southport.	Amphipods, Copepods, Annelids, Molluscs and An. tiss.
1	$2\frac{5}{8}$	Aug.	R. Dee.	A Shell and a Copepod.
39	$2\frac{5}{8}-4\frac{1}{4}$	Nov.	R. Mersey.	An. tiss., Copepoda, Gammarus, and Molluscs.

Plaice (*Pleuronectes platessa*).

2	$7-7\frac{1}{2}$	June	Crosby.	Tellina balthica and Cardium edule.
121	$7\frac{1}{4}-16\frac{1}{2}$	July	Horse Channel.	Mactra, Nereis, Carcinus and Tellina balthica.
234	$1\frac{3}{4}-14\frac{1}{2}$	Aug.	Horse Channel, River Dee.	Scrobicularia, Nereis, Carcinus, Pectinaria, Mactra, Tellina, Copepoda, Annelids, Mysis, Mollusca, Mytilus edulis.
8	$3\frac{1}{2}-4\frac{7}{8}$	,,	Morecambe.	Eurydice, and Lamellibranchs.
69	$1\frac{3}{4}-7\frac{1}{2}$	Sept.	,,	Annelids, Copepods, Cumacea, Amphipods, Lamellibranchs.
39	$2-5\frac{1}{2}$	Oct.	,,	Sponges, Cumacea and Copepoda.

Plaice (*Pleuronectes platessa*).

No.	Size in inches.	Month	Locality.	Food.
44	$1\frac{3}{4}-6\frac{1}{4}$	,,	Rock Channel.	Shrimps and Atylus swammerdamii Crustaceans, Annelids and Amphipods.
96	$2-7\frac{1}{8}$	Nov.	Garston.	Sponge, Cumacea, Scrobicularia, Amphipods, Mactra, annelid and shrimps.
16	$1\frac{3}{4}-9$	,,	Morecambe. Heysham Lake.	Tellina, Cardium, Scrobicularia Cumacea and annelids.
9	$4\frac{1}{4}-9$	,,	Morecambe.	All empty.

Dab (*Pleuronectes limanda*).

1	$6\frac{7}{8}$	June	Crosby	Tellina
20	$7\frac{1}{4}-10$	July	Mersey Horse Channel.	Ophioglypha albida, Pectinaria, Mactra, Tellina balthica and Nereis
20	$1\frac{7}{8}-10\frac{1}{2}$	Aug.	Horse Channel. River Dee	Ophioglypha albida, Pectinaria Pagurus, Portunus, Nereis, Mactra Copepods, Amphipods, An. tiss.
3	$3\frac{1}{2}-7\frac{1}{2}$	Sept.	Morecambe.	Mytilus edulis, Amphipods and Cumacea.
6	$1\frac{1}{2}-3\frac{1}{2}$	Oct.	,,	An. tiss.
88	$1\frac{3}{4}-5$	,,	Rock Channel.	Atylus swammerdamii, Gammarus locusta, Mysis, Campanularia, Idotea linearis, Cumacea and Donax.
109	$1\frac{1}{4}-7\frac{1}{2}$	Nov.	Garston.	Algæ, Sponge, Cumacea, Copepoda An. tiss., shrimps, Scrobicularia, Campanularia, starfish, Mactra, Ophiothrix, annelids.
9	$3\frac{3}{4}-6\frac{1}{2}$	,,	Morecambe.	Crangon and Carcinus.

Cod (*Gadus morrhua*).

8	$3-4$	Aug.	Morecambe.	Crangon, Mysis, Amphipods.
6	$2\frac{3}{4}-4\frac{3}{4}$	,,	R. Dee.	Crangon, Mysis.
25	$3-6\frac{1}{8}$	Sept.	Morecambe.	Crangon, Carcinus, Shell and Fish Amphipods, Mysis.
13	$3-6\frac{3}{4}$	Oct.	,,	Crangon, Carcinus, Mysis, Whiting, Amphipods and Isopods.

Cod (*Gadus morrhua*).

No.	Size in inches.	Month	Locality.	Food.
71	$3\frac{1}{4}-16$	,,	Rock Channel, Garston.	Crangon, Pandalus, Mysis, Portunus, Ammodytes, Pagurus, Pleuronectids, Gammarus, Idotea, Scrobicularia, Carcinus, Annelids.
52	$3\frac{3}{4}-9$	Nov.	Rock Chonnel.	Crangon, Carcinus, Mysis, Pagurus, Pandalus, Arenicola, Copepods, Cumacea, Amphipods, Annelids.
18	$2\frac{1}{2}-5\frac{3}{4}$	,,	Morecambe.	Crangon, Mysis, Carcinus, Portunus Amphipods and Fishes.

Whiting (*Gadus merlangus*).

63	$3\frac{1}{8}-5$	Aug.	R. Dee.	Crangon, Corophium, Eurydice, Mysis, Mytilus, Amphipods, Fishes, Cumacea, Annelids, Copepods.
17	$3\frac{1}{2}-4\frac{7}{8}$	,,	Morecambe.	Carcinus, Corophium, Pagurus, Amphipods, Fishes.
33	$2\frac{7}{8}-5$	Sept.	,,	Crangon, Carcinus, Fishes, Shrimps, Amphipods.
13	$3\frac{3}{4}-5\frac{1}{2}$	Oct.	,,	Crangon, Corophium, Eurydice, Cardium edule, Algæ, Amphipods.
71	$2\frac{7}{8}-6\frac{3}{4}$	,,	Garston.	Pandalus, Crangon, Nephthys, Mysis, Clupea harengus, Nereis Pleuronectes limanda, Fishes and Amphipods.
10	$3-7\frac{1}{2}$	Nov.	,,	Pandalus, Mysis, Crangon, Fish.
16	$3\frac{3}{8}-4\frac{1}{2}$	,,	Morecambe.	Mysis, Crangon, Atylus, Fishes and Amphipods.

Armed Bullhead or Pogge (*Agonus cataphractus*).

5	$5\frac{1}{4}-6\frac{1}{2}$	May	New Brighton.	3 Carcinus.
13	$2\frac{1}{2}-4\frac{1}{2}$	June	Crosby Channel.	Crangon, Pandalus.
5	$3\frac{1}{2}-3\frac{7}{8}$	July	Morecambe.	Crangon, An. tiss.
1	$3\frac{7}{8}$	Aug.	R. Dee.	Crangon.
2	$3\frac{7}{8}-4\frac{3}{8}$	Sept.	Morecambe.	Crangon.
14	$2\frac{1}{2}-4\frac{5}{8}$	Oct.	,,	Crangon, Amphipods, Cumacea Eurydice, An. tiss.
4	$2\frac{3}{8}-3\frac{3}{4}$	Nov.	,,	Cumacea, Carcinus, Amphipods.
13	$1\frac{7}{8}-4\frac{1}{4}$	,,	Mersey, Rock Channel.	Crangon, Carcinus, Mysis, Alga, Amphipods.

Spotted Skate (*Raia maculata*).

No.	Size in inches.	Month	Locality.	Food.
1	$3\frac{5}{8}$	June	Crosby Channel.	Crangon.
9	$3\frac{1}{8}-8$	July	Horse Channel, Ribble.	Portunus, Crangon, Corystes, Nereis, Mysis and Pleuronectes.
4	$5\frac{1}{4}-9$	Aug.	Horse Channel.	Carcinus, Crangon, Mysis.
1	$7\frac{1}{4}$	Oct.	,,	Crangon.

Thornback (*Raia clavata*).

No.	Size in inches.	Month	Locality.	Food.
1	$6\frac{1}{2}$	July	New Brighton.	Crangon and Carcinus.
64	$4-10\frac{1}{2}$	Aug.	Horse Channel.	Crangon, Carcinus, Portunus, Pagurus, Pandalus, Mysis, Gadus merlangus, Molluscs.
6	$5\frac{3}{4}-6\frac{3}{4}$	Oct.	Rock Channel.	Mysis and Crangon.

I submitted a number of the smaller Crustaceans taken from the fishes' stomachs, and preserved in the laboratory, to the critical examination of my friend Mr. A. O. Walker who is an authority upon these animals and he has kindly indentified them all as follows :—

Fish.	Food.
Solenette (July, Blackpool)	*Diastylis rathkei.*
Sole (July, New Brighton)	*Diastylis rathkei.*
Sole (,, ,,)	*Diastylis rathkei, Ampelisca lævigata.*
Plaice (Sept., Morecambe)	*Pseudocuma cercaria, Bathyporeia pilosa, Microprotopus maculatus.*
Plaice (Nov., Garston)	*Diastylis rathkei.*
Dab (Sept., Morecambe)	*Atylus swammerdamii.*
Herring (Sept.)	*Corophium grossipes.*
Cod (Oct., Garston)	*Gammarus locusta, Atylus swammerdamii.*

Cod (July, Piel I.)	*Gammarus marinus, Sphæroma serratum, Corophium grossipes.*
Cod (Sept., Morecambe)	*Gammarus marinus, Bathyporeia pilosa.*
Whiting (Aug., Morecambe)	*Idotea marina, Bathyporeia pilosa, Corophium grossipes.*
Whiting (Aug., R. Dee)	*Diastylis rathkei, Atylus swammerdamii.*
Whiting (Aug., R. Dee)	*Cuma scorpioides, Diastylis rathkei.*
Whiting (Sept., Morecambe)	*Bathyporeia pilosa* (including *B. pelagica* and *B. robertsonii*), *Atylus swammerdamii, Microprotopus maculatus.*
Whiting (Sept., Morecambe)	*Bathyporeia pilosa, Atylus swammerdamii.*
Whiting (Oct., Garston)	*Atylus swammerdamii.*
Whiting (Oct., Morecambe)	*Corophium grossipes, Sphæroma serratum.*
Pogge (Oct., Morecambe)	*Pseudocuma cercaria, Pontocrates arenarius.*
Pogge (Oct., Rock Ch.)	*Atylus swammerdamii*, and some young shrimps and prawns.
Skate (Aug., R. Dee)	*Gastrosaccus spinifer.*

Mr. Walker adds that it is remarkable that all these Crustacea are shallow water forms. Most if not all of the species inhabit a sandy bottom. One, *Corophium grossipes,* inhabits mud banks which are bare for hours every day and sometimes for two or three days together during neap tides in the Dee, where there are several square miles closely perforated with their holes. It is a surprise also to find *Diastylis rathkei* occurring so frequently. The absence of two of the commonest species

of shore-haunting Amphipoda on this coast, viz., *Calliopius leviusculus* and *Amathilla sabini* is also interesting.

Sole and Solenette.

One of the most important fisheries in this district is the Sole fishery, and this is probably one which might be considerably improved in the future by artificial fertilization and hatching. The Sole spawns in spring and early summer, and from our statistics in this neighbourhood I have selected the following as giving some idea of the growth during the first year:—

Aug., Horse Channel, 2 inches.

Oct., Blackpool, Ribble and Hilbre, 2½—4 in.

Nov., Blackpool, Southport and Rock Channel, 3—4 in.

Dec., Liverpool Bar, 3½ in.

April, Horse Channel and Crosby, 5 in.

May, Crosby Channel, 6 in.

According to the observations of Cunningham at Plymouth the young soles do not there pass the first year of their lives (3 to 12 months old) in the shallow waters, but somewhere outside the 10 fm. line; but all the localities which I have given above for young soles from 2 to 5 inches in length are in shallow water, being on an average about 4 or 5 fms. Here, as elsewhere, we find the young soles in shallow water the following summer, when they are over a year old; but they probably do not become sexually mature until the end of the second year. There is apparently considerable individual variation in size, but at the end of the first year the young soles are on an average about 5 or 6 inches in length, and at the end of the second year are about from 7—9 inches in length.

Every sole ought if possible to be allowed to come to sexual maturity and spawn before being caught. It is most desirable, as has been suggested in various quarters

lately, that a minimum size limit should be imposed so as to prevent fish which have not yet arrived at sexual maturity from being taken. We have lately commenced observations in the laboratory of the smallest mature and the largest immature individuals we can find of each species, in our district, and these will be carried on regularly through the coming breeding season.

A good deal has been said and written of late years about the destruction of young soles by shrimpers and by other fishermen; and in this particular neighbourhood there has been a strong impression that much damage was being done to the sole fishery by the capture of immature individuals a few inches in length. The general question of the destruction of immature fish by shrimpers I shall return to further on; but one of the first matters established in our Fishery Laboratory was that the capture of young soles here was happily not quite such a serious matter as had been supposed, for we found that a very large proportion of the so-called immature soles were not young edible or black soles (*Solea vulgaris*) at all, but were more or less full grown individuals of the Solenette (*Solea lutea*) a totally distinct though closely allied fish which does not grow larger than about 5 inches in length and so does not become of economic importance. We find the solenette sexually mature in this neighbourhood at sizes of about $3\frac{3}{4}$ ins. and upwards in length, while the smallest sexually mature true sole is at least twice that size.

To give an idea of the relative abundance of soles and solenettes of about the same size, and to show what foundation there was for the supposed great destruction of young soles, I may quote an instance from the Laboratory diary:—"On May 9th, 1892, 20 specimens of small soles trawled from a sandy bottom, in shallow water, were sent by Mr. Dawson for examination. Of these 19

were *Solea lutea* and only one of them was a true sole (*Solea vulgaris*)."

It may be of service in helping others to distinguish solenettes from half grown soles, if I give here the chief distinguishing features of the two species. Good figures of them will be found in Day's "British Fishes," Pls. CVI and CVIII, and in Cunningham's "Monograph on the Sole," Pls. I—VII.

(1) On the under side of the snout in *Solea vulgaris* the villi or little white tags are closely crowded together and irregular in arrangement, while in *Solea lutea* (solenette) the villi form fringes round the edges of quadrangular depressions of the skin, and so give rise to a reticulate pattern.

(2) The general colour is darker in *S. vulgaris*, more of a reddish brown in *S. lutea*; moreover in the latter the dorsal and anal fins are marked transversely by numerous narrow dark stripes, which are not present in the common sole. These stripes are caused by every 6th or 7th fin-ray being of a deep black colour, and this series of narrow bars across the fins is on the whole the most readily noticed reliable character by which the two species can be distinguished in this neighbourhood.

(3) In *S. vulgaris* the dorsal fin has from 83 to 90 rays, the anal fin has from 66 to 74, and the scales of the lateral line are from 149 to 166 in number. In *S. lutea* the dorsal fin has from 69 to 77 rays, the anal fin has from 53 to 63, and the scales of the lateral line are from 62 to 68 in number. These characters hold good for immature fishes as well as adults.

(4) In *S. vulgaris* the scales from any where about the middle of the body have from 10 to 16 radiating spines on their posterior border, while in *S. lutea* a scale from the same region has from 16 to 22 radiating spines (Pl. IV.).

There is an impression among some fishermen who have noticed that *S. lutea* is a distinct fish from *S. vulgaris*, that the scales in the former are much larger and rougher than in the latter. This is only true if soles and solenettes of the same size are compared together. We have examined the scales carefully in the laboratory, and drawings of their appearance under the microscope will be found on Pl. IV. Figure 1 shows the scale of the adult solenette, and fig. 2, the scale of a sole (immature) of the same size; while fig. 3, shows the scale of an adult sole. It is evident then that if you compare adult sole (fig 3) with adult solenette (fig. 1) the former has a scale considerably larger than that of the latter, but if you compare the half grown sole with the adult solenette then the latter has the larger scale. These figures show also the more numerous radiating spines on the posterior border of the scale of the solenette, referred to above.

The important question now arises—Does the solenette compete with the sole in the struggle for existence, and may we not be benefitting the sole and improving the sole fishery by killing off large numbers of the solenettes? The first thing to determine clearly is, are the two species ever found together on the same ground? There is no doubt from the trawlings carried on by Mr. Dawson and the bailiffs that they are. On July 27th, in the Horse Channel, near Liverpool, 68 soles were taken along with 240 solenettes; on July 15th in the Ribble Gut 12 soles were taken along with 435 solenettes; on August 23rd in the Horse Channel 71 soles were taken along with 110 solenettes; on August 13th, same locality, 134 soles with 250 solenettes; on August 12th, in Welshman's Gut, 38 soles with 9 solenettes; and on Sept. 5th, at mouth of Ribble, 9 soles with 135 solenettes. Each of these cases is one haul, and a large number of other similar cases

might be cited from our statistics. On the other hand Mr. Ascroft and others who have an extensive practical acquaintance with the fishing of the district, seem to think that the two species are not found on the same ground, but that the sole is more abundant outside the banks and the solenette in the channels inside, and that the sole lives usually on a muddy bottom, and the solenette on sandy ground—the prevalent colours of the two species in our neighbourhood certainly favour this latter view. However there can be no doubt that for a considerable time in summer the soles and solenettes are to a large extent associated together in the Horse Channel, Welshman's Gut, Ribble Gut, and other Channels where the sole fishing is prosecuted.

As to their food, our statistics show that they feed together on the same forms, various Crustacea, Annelids and Mollusca—with the addition of Copepoda in the case of the solenette. Consequently it is my opinion that, as far as our investigations go, there is considerable ground for supposing that the solenette which is very plentiful in our shallower waters—and, it must be remembered, is a perfectly useless fish from the economic point of view—really interferes with the sole and is probably accountable for a good deal of the enormous mortality which must take place amongst immature soles. If there was much destruction of young fish by larger carnivorous fish in our inshore waters, if for example the Turbot was an abundant fish, then the numerous solenettes might be of great use in serving as food and so giving the young soles a better chance of escaping being eaten. But that is not the case here, so I think there can be no doubt that it would do no harm to the sole fishery, and might do good, if the solenettes were killed off. We may regard with equanimity their capture in large numbers by Shrimp-trawlers

and others—so long as the men can be trusted to discriminate between the sole and the solenette—and while I would use every endeavour to get all the young soles returned to the water as speedily as possible in the hope of their recovery, I would allow the solenettes to be kept on board and made any possible use of.

If, as those best qualified to judge all seem to think, the sole fishery is declining because of the increasing scarcity of soles in our inshore waters, I would urge most strongly that steps should be taken *at once* by artificial fertilization and hatching to add to the numbers of the young in the district, and so increase the chance of a fair number surviving to maturity. It is undoubtedly more important in such cases of diminution to add to the numbers of the fish in the area than to put restrictions on the fishing. It may sometimes be necessary to do both, but the former (adding to the numbers) is the most efficacious step and the latter (restricting the fishing) taken alone may be useless if the fish population is much reduced. It probably holds good for all communities of animals that if they fall in a particular area below a certain level in numbers, and no fresh blood is imported, then they are doomed to extinction—the reason probably being that the number of young produced in each season is not sufficiently greater than the number killed off by normal (*i.e.*, regularly acting) causes to allow of a sufficient balance being present to meet the action of any abnormal (*i.e.*, unusual) causes, consequently at any time the existence of the reduced community may be threatened by some so-called accidental occurrence which would have comparatively little effect in a large community. I do not say that the sole fishery has arrived at this condition—it has happened with the Oyster fishery in various places—but the way to avert such a calamity is to meet it in time by artificial breeding and hatching, and so,

by adding to the number of young in the district, help the species to recover itself while it is still worth helping.

I think it is worth pointing out also that if the average size of a species of fish caught in a particular district is decreasing, then that is a sure indication that the area is being over-fished, and that it is high time to take steps to increase the supply of young fish and so let the species in question have a fair chance of keeping pace with the destruction going on. The decrease in size of the average fish shows that a greater proportion each year of the population is being prevented from becoming adult. In a fishery the aim should be, if it were completely under control, to adjust the deaths to the births, as you would the outflow to the inflow of a tank you wish to keep at a constant level.

The argument, sometimes heard, that since a species of fish which is becoming scarce from over-fishing can produce a very large number of eggs, it will soon recover in numbers if left alone, *i.e.*, if restrictions are put upon the fishery, is not a sound one. It is not by any means the fish that produce the largest number of eggs which are the commonest. The very abundant herring, which is perhaps the safest to last of all our fish, produces only about 30,000 ova as against the million of the very much rarer sole and the ten million of the comparatively rare turbot; while the dog-fishes which are apparently increasing very greatly in numbers and are said to be becoming a plague in some parts of the Scottish waters produce only a very few young at a time. The fact that a fish produces a very large number of ova indicates to the biologist that that species is exposed to very exceptional risks during its embryonic and other young stages, and that there is consequently such a great mortality that unless the huge number of ova started existence none would arrive at maturity. The

millions of ova then are no indication of abundance, but merely a provision against exceptionally adverse circumstances: it is also, however, man's opportunity. It gives him the chance of stepping in and by artificial hatching saving a large proportion of those that would otherwise be lost. This naturally leads to the subject of the

Destruction of Immature Fish, &c.

There can no longer be any doubt that enormous numbers of young edible fish—especially valuable flat-fish—are killed every year by shrimpers. The matter has been a subject of controversy in the past. Prof. M'Intosh* has drawn attention to the matter; but Dr. T. Wemyss Fulton of the Scottish Fishery Board was the first to attempt to give definite numerical statements as to the species, sizes, numbers, &c., destroyed in the year (see Scot. Fish. Bd. Rep. for 1890, and "Nature" for Nov. 19th, 1891.), and the numbers he gave were not very great, *e.g.*, one boat, in Solway, 110,000 plaice per year. But other investigators who have had much practical experience of trawling such as Mr. A. O. Walker and Mr. R. L. Ascroft consider that the numbers given by Dr. Fulton are much too low, or at any rate that destruction goes on in the southern part of our district to a very much greater extent.

Walker quotes Ascroft (*Nature*, Dec. 24th, 1891), as saying:—"Shrimping destroys more young fish than almost any other agency. I have seen in Formby Channel 10 cwt. of young flukes destroyed, not one the size of half-a-crown, by one boat, and there were sixty boats there that day;" and he (Walker) goes on to compute that these boats must have been destroying about twice as many young fish per week as Fulton gives for a year. From

* See especially his valuable article in "Nature" for Aug. 28th, 1890.

the differences of opinion expressed about that time it was evident that further exact statistics from different parts of the coast were badly wanted, and it should be remembered that at the London International Fisheries Conference in 1890 the following resolution proposed by Dr. P. P. C. Hoek the delegate from Holland (a well-known authority on fishery matters) was passed unanimously:—"This conference considers it desirable that before the official conference meets, the different nations interested in the Sea-Fisheries of European waters will collect with as little delay as possible, sufficient information, scientific as well as statistical, with regard to the damage done by the capture of under-sized fish by their fishermen." This is now being done in Scotland by the Scottish Fishery Board, at Grimsby by Mr. Ernest Holt, and in the south by the Marine Biological Association at Plymouth, and we shall naturally be expected to do our part here. Our shallow inshore waters here are known to serve as "nurseries" for young flat-fish, in fact the areas over which the shrimpers work are at certain times swarming with young fish from immediately after post-larval stages nearly up to maturity. Those interested in the fisheries elsewhere naturally look to us to give exact information as to the state of affairs in this district, and I would strongly recommend that a systematic survey of these "nurseries" and a determination of the proportion of different species of young fish, and their sizes month by month, be made a regular part of the work of the new steamer. The valuable statistics which Mr. Dawson has already been able to take in the district give some preliminary idea of the immense numbers of these young fishes which are caught along with the shrimps. The following hauls will show that:—

July 27. Burbo Bank. Shrimp trawl out $1\frac{1}{4}$ hrs.
5785 immature food fishes to 2 qts. of shrimps.

Aug. 13. Horse Ch. Shrimp trawl out $1\frac{1}{4}$ hrs.
4616 immature food fishes to 5 qts. of shrimps.

Aug. 23. Horse Ch. Shrimp trawl out 2 hrs.
6827 immature food fishes to 5 qts. of shrimps.

Aug. 25. Horse Ch. Shrimp trawl out $1\frac{1}{4}$ hrs.
5802 immature food fishes to 2 qts. of shrimps.

Feb. 4. Blackpool closed ground. Shank net out $\frac{1}{2}$ hr.
1199 immature food fishes to $3\frac{1}{2}$ qts. of shrimps.

Altogether over the months from Feb. to Aug., Mr. Dawson's statistics show that the number of immature fish to 1 qt. of shrimps caught by means of the shrimp trawl on our ordinary shrimping grounds varies from 87 to 687, the average being 310.

Various suggestions have already been made as to a remedy for this most unfortunate and wasteful state of affairs. It has been proposed that the shrimp net should have at its extremity a light wooden frame bearing a wire sieve with long narrow meshes of such a size as would allow the small flat-fish to wriggle through while keeping back the full grown shrimps. This might do if it could be kept clear, but possibly it might be liable to get choked up and so do little good. Mr. Dawson has devised a modified form of shank net with a horizontal bar about 3 ins. off the bottom to which the lower part of the net is attached. The theory is that as the shank frame comes along and disturbs the bottom the shrimps will spring upwards above the level of the bar and so be caught, while the young fish will swim along nearer the ground and so escape under the bar. Mr. Dawson has had this form of shank net made and has used it in this district and he reports that it "takes a much less number of young sea-fish and quite as many shrimps as the old form. In fact, on dirty ground more shrimps were taken, owing to a large proportion of the debris passing underneath the net and

not choking it, as was the case with the old style of net." Mr. Walker in a letter to "Nature" (vol. XLV, p., 176) states that in his experience in the estuary of the Dee the shrimps are further inshore than the young fish and he proposes that in that locality shrimping should only be allowed within quarter of a mile of the shore. He further recommends the formation of young fish preserves on selected grounds along the shore by laying down large boulders which would effectually prevent trawling on that ground. This may possibly be worth doing in a few special localities, but obviously cannot be generally adopted. The use of the Shrimp trap, as used on the French coast, at Croisic and elsewhere should be tried here; and I am inclined to think that Shrimp culture as detailed below (p. 35), might be carried on with success in our estuaries and if it proved remunerative, and was likely to give employment to a number of the present Shrimpers, that would make it easier to impose restrictions upon trawling in areas where, and at such times as, young fish are known to be present in large numbers.

It is a much disputed question whether it is any use returning to the sea the young fish which have been brought up in a trawl-net and are emptied on to the deck in various stages of more or less exhausted vitality. If it is the least use, if even a small proportion of them will eventually recover, then very strict regulations should be made and enforced compelling the men to return the young fish to the sea at once. In a case like this where it must be very difficult to be sure that regulations are being strictly carried out it would be important to try and educate public feeling amongst the men by teaching them the vital necessity of letting the young fish have a chance of growing to maturity.

The Scottish Fishery Board have been endeavouring

to determine practically whether the young fish brought up in the trawl-net are worth returning to the sea, and I hope that similar "vitality investigations" will be carried on on board the fishery steamer here. A large tub or wooden tank should be fixed on deck through which by means of the hose and a waste pipe a circulation of sea water can be kept up. Then after each haul of the trawl-net a few fish should be picked out and put in the tub, their species, size, and condition (*e.g.*, "lively," "exhausted," &c.,) being noted on a form, along with a statement as to the time trawl was down and kind of net used. The fish should be allowed to remain a definite time, say 30 or 40 minutes, in the tub and then the result (*e. g.*, "recovered," "dead," &c.) would be added to the form. Such statistics would give a definite idea of the proportion of fish caught under certain conditions which might be reasonably expected to recover if returned promptly to the sea.

In making any regulations in regard to immature fish the aim should be to allow as many fish as possible to spawn once at least before being caught. Hence it becomes of importance to know *for our district* the size at which the various species become sexually mature. During this coming breeding season we shall record the size, and the condition as regards maturity, of all fish examined, with the view of arriving at the minimum measurement at maturity, and also the maximum of immaturity so as to fix upon a fair average size below which no fish should be taken. We want also to know *for our own district* (some of these things cannot be taken from elsewhere, such as the east or south coasts) exactly when (at what age) each species spawns, and what the rates of growth are,* and the average sizes in successive years, exceedingly difficult matters to determine, as artificially reared fish may be

* See also Cunningham, British Association Report for 1891, p. 658.

misleading, and there is probably great individual variation. Such information as we want can only be got by continuous work at sea, tow-netting and trawling periodically, as Mr. Dawson proposes to do with the new steamer, supplemented by work in the laboratory in determining the exact condition of the reproductive organs and in identifying the ova and larvæ of the fish.

Another important matter is the movement of the fish throughout the year in our area, and the valuable statistics which Mr. Dawson has been able to collect already throw same light upon that. There seems no doubt that here, as they have found in Scotland also, the Plaice, and probably other fish, spawn at considerable distances from the land, well outside the 3 mile limit, on off-shore banks.

The advantages to a species of fish producing pelagic eggs in spawning over a bank far out from land are obvious. There is less chance of the embryonic and larval stages being washed ashore; without being in too deep water, they are removed from the many dangers of a coast; they are more likely to be in water of suitable and fairly constant specific gravity; and there is more chance of the larval stages finding suitable nutriment in the embryos and other young stages of the numerous invertebrata which frequent such banks, and which rise up from bottom to surface in their younger stages and sink down again to bottom in later stages, so giving the young fish in the intermediate waters two chances at their prey. It is only then at a somewhat later stage of the early life history that the young Plaice, &c., come into the shallow inshore waters which we talk of as "nurseries." There is then both a vertical circulation, from near the bottom (as ova) up to near the surface (as embryos and larvæ) and then down again (as immature fish) to the bottom, and also a horizontal circulation, from the offshore spawning

ground (as ova and embryos, &c.,) in to the shallow bays and "nurseries" (as immature fish) and then out again (as adult or mature fish) to the offshore banks. From this it follows that we have not really command of the fish population of a particular bay, or coast, unless we also have control of the off-shore waters to which the spawning fish from our bay migrate. It is possible that trawling outside amongst the spawning fish may do great damage to that fishery in the district. If it is impossible to restrict the off-shore trawling during the spawning season, at least perfectly mature fish on the point of spawning might be "stripped" and the ova artificially fertilized and either returned to the sea or conveyed to a Hatchery.

Need of a Sea-Fish Hatchery.

Complaints as to the gradual falling off of the more valuable sea fisheries come from various parts of the coast and also from other European countries; and the trawling statistics of the 'Garland' in the territorial waters, where the Fishery Board for Scotland has absolutely prohibited beam-trawling for some time back, show that little or no increase of flat fishes in that district has taken place. So they have now come to the conclusion in Scotland which had been arrived at previously in some other countries that the only thing that will enable a fishery to recover when once it has been over worked is artificial propagation, and rearing. Sea-Fish Hatching establishments have now been erected in the United States, Canada, Newfoundland, Norway, France, Italy, Denmark, and other countries, in all cases with satisfactory results. In the United States they consider the important Shad fishery to have been revived and greatly improved as a result of artificial cultivation. In Norway they hatch at Flödevig near Arendal hundreds of millions of young Cod annually. In

Newfoundland over 500 million of young Lobsters were hatched and set free last season, in addition to millions of Cod. Even the comparatively small hatchery just erected at Dunbar, and which I have had the advantage of visiting through the kindness of Dr. Fulton, will accommodate 80 million eggs at one time, and can of course by choosing the fish judiciously be used for many such batches in succession during a season—say from January to July.

I would now strongly advocate the establishment of a small Sea Fish Hatchery for this district, such as I suggested in my memorandum to the Committee dated April 26th, 1892; and I am of opinion that by far the best situation for such a purpose would be Port Erin at the South end of the Isle of Man. The Liverpool Marine Biology Committee have erected at Port Erin a small Biological Station in which work has now been carried on since last June so I can speak with an intimate knowledge of the conditions there, and I can confidently say that there is no place on the Lancashire or Cheshire coasts which would present equal advantages. The sea-water at Port Erin is perfectly pure—a primary requisite—while along our own coasts the water seems not to be any where sufficiently pure and free from mud and decaying matters to be used for hatching purposes. At Port Erin there are rocky creeks which could be readily enclosed to serve as ponds for collecting the spawning fish in, and there is one large tidal pool on the shore close to the present Biological Station which might at very small expense, by the erection of small pieces of wall between the rocks (see Pl. V.), be enlarged to more than twice its present size so as to form a pond measuring about 40 by 20 feet and 6 feet in depth. Another decided advantage in having the Fish Hatchery at Port Erin would be that time, labour, and

expense might all be saved in the working of the concern if some arrangement could be made with the Liverpool Marine Biology Committee to put the two establishments under the charge of a joint curator and share the expense. The Biological Station would then be a most useful adjunct to the hatchery, and the benefit derived from the presence of the scientific specialists working at the station would be very great.

It is scarcely necessary to point out that the young fish hatched would not be set free at Port Erin, but would naturally be taken across in tanks by the fishery steamer and set free on the Lancashire and Cheshire coasts upon suitable ground; so that this suggested erection of a hatchery at Port Erin would be no case of the application of funds to a foreign purpose or for the benefit of an area outside the Committee's District, but would be merely the making use, for our own purposes, of a suitable spot on the nearest available rocky coast because we have no sufficiently good ground on our own shores.*

In concluding this section of the report dealing with the fishes proper I would like to quote, and endorse, the

* In regard to the probable cost of a Sea-Fish Hatchery, Dr. T. Wemyss Fulton, scientific secretary to the Scottish Fishery Board, has kindly given me all possible information about the cost of the work and apparatus at Dunbar so as to enable me to put down the following figures as a rough approximation to the cost of a small establishment which would contain 10 hatching boxes, thus having a capacity altogether of about 40 to 50 millions of cod eggs at a time :—

Wooden house, say 30 ft. by 25 ft., concrete floor	£50
10 hatching boxes at about £3 each	30
Filtering apparatus. &c.	15
Steam Pump, to throw say 1000 gals. per hour, say ...	25
Boiler for this, say	60
Piping, &c., say...	50
Making pond, or enclosing creek for spawning fish, say ...	50

If water power, or a windmill pump could be made use of, the total both of initial and working expenses would of course be greatly reduced.

following sentence expressing the opinion of the Fishery Board for Scotland :—* "From this review of contemporary Sea Fisheries in other countries it appears that there is a general complaint as to the diminution of fish in the inshore waters; that measures for the prohibition of the landing or sale of immature fish have been adopted or are being considered in many countries; that the artificial propagation of sea fish is now being prosecuted with vigour by the fishery departments of several states; and that scientific investigations into the fisheries, by means of surveying expeditions, marine laboratories, &c., are being greatly developed and extended."

Edible Crustacea—the Shrimp.

The only edible Crustacea which are at present of economic importance from the fishery point of view in this district are the Shrimp (*Crangon vulgaris)*, the Prawn, (*Palæmon serratus*), and the Shank (*Pandalus annulicornis*); but if a hatchery were established at Port Erin, it would probably be worth while to hatch and rear there in the rocky creeks, the Lobster (*Homarus vulgaris*), Crab (*Cancer pagurus*), and the Norway Lobster (*Nephrops norvegicus*), which latter is abundant in that neighbourhood.

The Prawn, with which the usually much more abundant Shank is commonly confused by the fishermen, has not yet been the subject of any special work in the laboratory; but Shrimps have been largely investigated during the summer and autumn both in regard to their food and their reproduction. To take the food question first, the most varied opinions are current amongst the shrimpers as to what Shrimps feed upon (see L. M. B. C. Reports No. 4, p. 32, and No. 5, p. 24); but the result of our

* See their Report vol. X., p. 21.

examination in the laboratory of more than 560 Shrimps is that they are chiefly carnivorous in their diet. We find in their stomachs :—Crustacean remains, such as Amphipods, small Crabs, young Shrimps, and Copepoda; also a considerable amount of Molluscan remains, such as small specimens of *Scrobicularia alba*, *Cardium edule*, and *Tellina balthica*. Annelids must also form a fair proportion of their food from the number of Polychæte setæ in the stomachs, with occasionally fragments of the tube of *Pectinaria*, and the horny jaws of a Nereid. More rarely the stomachs contain Foraminifera and small spines of Echini; and sometimes green seaweeds, minute filamentous and microscopic Algæ and Diatoms. We find from experiments on them in captivity that Shrimps will also eat practically any animal matters such as pieces of dead fish, other Shrimps, beef, &c.

The male Shrimps are less numerous, and are much smaller than the females, and so are comparatively rarely caught in the nets. It is a difficult matter to determine the sex in small specimens, and we find that even in fully formed sexually mature individuals the inner branches of the first abdominal appendages, which are the only external sexual characteristics to depend upon, do not show the markedly different conditions figured by Ehrenbaum.* We give now on Plate II. some figures showing:—(fig. 1) the entire second abdominal appendage of a large female Shrimp ($2\frac{3}{4}$ in. long); and (fig. 2) the entire first abdominal appendage of the same Shrimp to show the modification of the endopodite or inner branch (en.) which is shown more highly magnified in fig. 3, in the adult female; also (figs. 4 and 5,) the fully formed endopodites of the same appendage from two adult males ($1\frac{1}{2}$ ins. long); while fig. 6

* Zur Naturgeschichte von *Crangon vulgaris*. Berl. 1890, Taf. II., figs 15 A & B.

shows the corresponding endopodite of an immature female of about the same size ($1\frac{3}{8}$ inch) as the mature males. Figures 7 and 8 show the ovary and testis of the two mature Shrimps from which the appendages were taken.

It will be seen on comparing figs. 5 and 6 that the only differences in this endopodite between male and female Shrimps of the same length are (1) the size, the female branch being decidedly longer, and (2) in the arrangement of the setæ along the inner side. The female endopodite has only a small number (3—6) of short stout curved setæ or bristles, while in the male the setæ are more numerous, forming a continuous row, and are longer and more delicate and hair like.

In this neighbourhood most of the large female Shrimps spawned in November. They appear to cast their cuticles just before spawning. Many of the Shrimps caught in the end of October have recently cast their "skins," and the exuviæ are frequently taken in the Shrimp nets about that time.

A few Shrimps can be found at almost any time with "spawn" (embryos) on the abdomen, but there seem to be two chief periods in the year here, just as Ehrenbaum found on the German coast. The times here seem to be late Autumn (beginning of November) and early Summer (April and May.) About 5000 eggs are deposited on the abdomen at a time by a fully mature Shrimp.

It is very evident even from the few observations we have yet made that there are very many enemies to the Shrimp in all stages of its existence in this neighbourhood. We find it frequently in the stomach of *Agonus cataphractus* and *Liparis montagui* and many other fish. Skates eat it in enormous quantity, the large stomach of the fish being sometimes distended with a quart or so of Shrimps.

The enormous variations in the catch of Shrimps from

time to time in the shallow waters of our district require further investigation. At times Shrimps are very scarce, having apparently either migrated to deeper water or buried themselves in the sand.* This seems to be largely the result of temperature variations. Periodic observations at fixed stations, the Shrimp trawl being down for the same time, and at the same state of the tide, say once a week, should, supplemented by our work in the laboratory, give us a good deal of information in regard to the life-history of the Shrimp throughout the year.

I have suggested above, in connection with the destruction of immature fish, that Shrimp culture might be carried on in our estuaries. At any rate the matter ought to be tried on a small scale experimentally. A sheltered creek or bend in one of the estuaries should be closed in by stakes and wattling, like a fishing weir, so as to keep out Skates, Codling, Crabs, and other enemies. This preserve could then be stocked with Shrimps—which might be fed with any fish refuse—and if it were found that the young stages when hatched out could be kept inside the enclosure and reared, the probability is that in the absence of enemies and with abundance of food the numbers would increase very greatly.

Edible Mollusca.

The edible mollusca of chief importance here are the Cockle (*Cardium edule*), and the Mussel (*Mytilus edulis*), and a certain amount of work has been done on both of these shell-fish in the laboratory.

The Cockle.

In examining for food, specimens sent by the bailiffs the first thing noticed was the very large proportion of individuals in which the stomach was quite empty, the reason

* See Trans. Liverpool Biological Society, vol. V. p. 49 ; and vol. VI. p. 32.

no doubt being that such a long time had elapsed since the animal's last opportunity of feeding that the contents of the stomach had been digested and had passed on. Consequently we found it important, in enquiries into the food, to state that, if the specimens cannot be examined as soon as collected, they should be killed at once so as to stop digestion.

The food of the Cockles examined in the laboratory consisted of spores and other young stages of lower Algæ, filamentous Algæ, fragments, and other vegetable debris, Diatoms, Foraminifera, Sponge spicules, fragments of minute Crustacean appendages, such as Copepoda, and of the larval stages of higher Crustacea, all mixed with sand grains.

We have found that most cockles sent to the laboratory are infested by the minute Copepod, *Lichomolgus agilis*, recently described by Mr. Scott, but there is no reason to think that this commensal is in any way injurious to the cockle. There is also a similar Copepod in the mussel. Although there are five species* of cockle (the genus *Cardium*) which are found in this neighbourhood, still all the cockles sent to market belong to the one common species *C. edule*. Some of the men speak ot more than one kind, and of a smaller species, but although specimens from different beds may vary a little, in size, and colour, and thickness of shell, all that have been sent to the laboratory for examination, both large and small, are *C. edule*. Some specimens which were sent by Mr. Dawson on April 8th from one of the Morecambe Bay beds are very brown on the outsides of the shell and even along the inner edge of the valves and over part of the mantle lobes and siphons. We found that this staining is due to a deposit of amorphous oxide of iron, caused

* See Fauna of Liverpool Bay, vols. I. and III.

probably by proximity to some iron-laden stream. These cockles seemed to be otherwise normal, and perfectly healthy.

In some parts of the district there is usually a filamentous brown tuft appended to the posterior (upper) end of the animal, which the fishermen believe to be a part of the body, and to be, when seen projecting from the sand, a sure indication of the presence of the cockle. Mr. Dawson drew my attention to the matter during a visit in May to the cockle and mussel beds in Morecambe Bay, and on obtaining specimens and examining them I found that the tuft consisted in many cases of the zoophyte *Obelia flabellata* and in other cases of a filamentous Alga (sea-weed—a species of *Sphacelaria*). Both Zoophyte and Alga are attached to the extreme posterior edge of the valves which is, in the natural position of the animal, the part which is highest or nearest to the surface of the sand. Of course the tuft of Zoophyte and Alga have no special connection with the cockle; and their fairly constant presence in some localities is merely due to the circumstance that the cockle shells are, compared with the sand grains by which they are surrounded, relatively stable objects to which the free swimming young stages have attached themselves as they would to a rock—and they have chosen the posterior end of the shell because that is the point nearest to the sea above, from which they came and into which they must project. There is absolutely no ground for the idea that the tuft is in any way injurious either to the cockle or to the person who eats the cockle.

The cockle in our neighbourhood spawns in summer. The specimens dissected in the laboratory in June and July were many of them mature males and females with fully developed ova and spermatozoa. The number of ova laid is very great, but of course a large proportion are

cut off in the early embryonic stages. Still there is probably quite a sufficient supply of young each year to keep up our very valuable cockle beds if we act with ordinary prudence and common sense in regulating the fishing, and taking care of the young animals. Biological knowledge of the life of the animal suggests that cockles should not be taken from the beds until they are quite adult and of full size—about an inch in length; that the beds should be as little disturbed as possible; that the younger ones should as far as possible not be removed from the sand, and if young and old have to be collected together they should not be taken away to be riddled or sorted out elsewhere, or if riddled on the spot the young which pass through the riddle should not be left in a heap, as in these cases the majority of the young will probably die. The fishermen *ought* to be careful to leave the young ones he rejects in such a situation that they can readily regain their former position in the sand and live on uninjured. We must remember that the object of any regulations should be, not merely that the young cockles should not appear in the market, but that *they should not leave their homes*.

The Mussel.

The Mussel requires still more attention than the cockle, because it is not protected by sand and because it requires something to hold on to; and I am persuaded that much could be done in this neighbourhood in the way of Mussel culture. Many parts of our shores, especially up the estuaries, seem well fitted for the growth of mussel beds if there was anything—such as stakes and wattling—for the young mussels to attach themselves to. The supply of embryonic mussels every year is abundant. At Hilbre Island and Caldy Blacks and other places in

the estuary of the Dee, as well as elsewhere, they settle down after the free swimming stages in such profusion that the rocks, seaweeds, zoophytes, and any other relatively solid objects are blackened with the minute shells. Practically none of these grow to maturity. Some have settled down on unsuitable objects, many are crowded out by their neighbours, the star-fishes eat enormous quantities, but the greater number on account of their not having been able to obtain a firm point of attachment for their byssus threads are swept off, by the waves, in sheets when they are from $\frac{1}{4}$ to $\frac{1}{2}$ an inch in length and are rolled about in masses on the sands till they decay. This miserable waste could probably be prevented by providing fixed objects for the mussels to attach to, and by taking care of the young beds when once they were established, by thinning out from some places and laying down in others, by keeping carts, &c., from going over the beds and crushing the animals, and finally by preventing the mussels from being collected until they are of a fair size—say $2\frac{1}{2}$ inches in length.

We have examined a large number of mussels from various parts of the district in the laboratory in order to determine their food, spawning time, and anything else possible in regard to their conditions of existence. The stomachs generally contained plenty of food, consisting entirely of microscopic matters, such as the spores of Algæ, very many Diatoms of different kinds, fragments of Algæ and vegetable debris, Sponge spicules, Foraminifera, remains of Copepoda and of Nauplei, and fragments of Zoophytes.

A well established mussel bed usually supports large numbers of microscopic lowly plants and animals, which find shelter in the crevices between the mussels, and which supply with food not only the molluscs but also the young fish and the food of the fish of the neighbourhood.

Conclusion.

This first report* on the Sea-Fisheries Laboratory only deals with eight months work, and that work, commenced suddenly in the middle of the summer, with a new assistant strange to the ground, has been of necessity to a large extent tentative and introductory. We may reasonably hope that much more systematic work will be possible during the coming season, now that there is a permanent steamer suitable for work at sea, and that the bailiffs know what we want sent by them, and that we in the laboratory know better what the nature and products of the different parts of the district are; and naturally—as has been found in other places—the value of the work will increase year by year as the statistics are accumulated, and as the facilities for carrying on the work increase. For I hope this is only the beginning of a very much larger system of the application of scientific methods and knowledge to the investigation of the fisheries of our neighbourhood and of the country generally. When we consider what is being done elsewhere for the biological investigation of sea-fisheries, we realize what a very small beginning has been made, and how much more Lancashire ought to do. In America the U.S. Commission of Fish and Fisheries have a number of laboratories, stations, and hatcheries, a large staff of Naturalists, and devote a large grant annually to the scientific work. Germany no sooner obtained possession of Heligoland than she established there a Biological Station with a staff of Naturalists to investigate the fisheries of the neighbouring German Coasts. France, Italy and other European states are devoting much time and money to the benefit of their fishing industries. Finally the Scottish Fishery Board has a Biological Station, as well as a Fish Hatchery, at Dunbar, another Biological Station (under Prof. M'Intosh) at St. Andrews, a Lobster

* In which, for brevity, much reference to published papers has been omitted.

Hatchery at Arran on the west coast, and a staff of Naturalists constantly at work both at sea and in the laboratories.

In conclusion, I believe the most pressing needs, in the interests of our fisheries, now to be (1) a series of exact periodic observations to be carried out from the steamer, and (2) the establishment of a Hatchery, such as I have suggested above should be erected at Port Erin, alongside the Biological Station.

I append to this report (A) a scheme of suggested investigations at sea, and (B) a first list of the Fishes of the district with their common names.

APPENDIX A.

Scheme of Investigations at Sea.

It is very important in connection with our investigations in the future, that we should have perfectly definite statistics as to the Fauna (*i.e.*, the assemblage of fishes and other animals which form the food and enemies of the fishes), and also the physical conditions, in particular parts of our district, taken periodically—so that the condition and population of a particular bank or channel or bay may be traced month by month throughout the year. Consequently I beg to suggest to the Committee that as soon as the permanent steamer has got to work the following scheme should be adopted. It is founded to a large extent upon the methods employed by the Fishery Board for Scotland, on their steamer the "Garland" where I have myself seen all the processes at work, and have discussed the results, extending over some years, with Dr. Fulton, the Scientific Secretary, and Mr. T. Scott, the Naturalist, to that Board. My proposal is:—

1. That a number of "trawling stations" should be marked off on the chart of our district. The exact lines and extent of these for the first year's work might conveniently be fixed upon by Mr. Dawson and myself from our present knowledge of the area, the guiding idea being to investigate those spots where we have some reason to think that food fishes congregate at some season for a special purpose such as spawning or feeding. The Blackpool "closed ground" would naturally be one station, another might be the "Horse Channel" or "Hilbre Swash," and a couple should be well out to sea, on the off-shore spawning grounds. These "trawling stations" should be lines the extremities of which are determined by observations of parallax on shore, ("cross bearings") or from buoys or other fixed points, so that as far as possible the same line and the same extent of ground should be trawled over in each observation.

2. It should be the rule that (weather permitting) each station (A, B, C, &c.) should be trawled over at least once a month. It would be still more satisfactory, if it could be so arranged, that each station should be trawled over twice a month in opposite states of the tide, as it is very important in comparing such periodical observations with one another, that the conditions under which they are made should be similar. By this plan there would be a series of monthly observations at each station at flood tide and another series at ebb tide.

3. In taking each observation I would recommend that the following course of procedure be followed:—

a, the ship is brought to one end of the Station and stopped,

b, a white enamelled disc for testing the transparency of the water is lowered over the side by means of a line on which quarter fathoms are marked and the depth at which the disc disappears is noted,

c, a cup thermometer is immersed a few inches below the surface, and the temperature read and noted,

d, a bottom reversing thermometer is lowered on a sounding line, and the bottom temperature is noted, the depth at the same time can be verified to show the ship is on the right spot,

e, a bucket of water is drawn from the surface and the specific gravity (at the particular temperature) taken and noted,

f, by means of a "water bottle" a sample of water from the bottom is brought up and the specific gravity (at the particular temperature) taken, and noted,

g, note on a form the date, station, time, state of tide, wind, weather, state of sea, air temperature, and barometer reading,

h, lower the trawl, with a bottom tow-net attached to one end of the beam,

i, put out a surface tow-net. At certain times and localities it might be desirable to add a "mid-water" tow-net, after the plan adopted by Prof. M'Intosh with such success, for the capture of the larval and post-larval stages of food fishes; also it would be a good plan to have an ordinary Naturalist's dredge down for a portion of the time the trawl is overboard—say half-an-hour—in order to determine whether it gives any different results in regard to the nature of the bottom, and of the fauna.

On arriving at the end of the "Station" the following would be the procedure :—

k, haul in surface tow-net and transfer contents to large wide-mouthed jar of clear sea-water labelled "surface tow-net" and put it aside in laboratory, if mid-water net is used, treat it in the same way,

l, bring in the trawl net,

m, transfer contents of bottom tow-net to large jar of sea-water labelled "bottom tow-net," and put aside in laboratory,

n, take again the observations noted under *b*, *c*, *d*, *e*, *f*, and *g*, at other end of Station,

o, examine trawl contents, and sort out the fishes on one side and the invertebrates on the other,

p, look over invertebrates and note on form a rough approximation to numbers of the prevalent common forms such as star-fish, common crabs, zoophytes, &c., which can be identified at a glance (these may then be shovelled overboard),

q, transfer any rarer or unusual invertebrates, or anything which for any reason requires further examination, to jars of clean sea-water, or if the examination cannot be made at once, to jars of methylated spirit to be forwarded to the laboratory at Liverpool,

r, separate out the different species of fish and note on a form, the species, numbers, sizes, and remarks about condition,

s, pick out a few of each species, small individuals as well as large, and transfer them to a tub through which sea-water is circulating (by means of hose and waste pipe), and leave them there for half-an-hour in order to test vitality,

t, if experiments on migration are being carried on, pick out for the purpose some of the more lively fish, attach numbered tags to them and record on a form number, fish, size, date, and locality, and then return them to sea,

u, examine as many of the remaining fish as there is time for, noting the following on a form, species, size, sex, condition of reproductive organs, and contents of stomach,

v, keep in spirit any abnormal individuals, or any so small that examination cannot well be made on board, to be forwarded to laboratory at Liverpool,

w, examine the surface and bottom tow-net gatherings, put aside before (*k*, & *m*,) note any prevalent organisms, strain off the water, and preserve the material left in a small bottle (labelled with date and station), to be forwarded to Liverpool for detailed examination.

With further experience of the work it may be found necessary in the future to add some further observations, directed towards the elucidation of special points, but in the mean time it seems to me that the above mode of procedure if systematically and carefully carried out will give us much valuable information of the kind we want. And it should be borne in mind that *it is only after such a series of exact observations have been taken for a year or two that we can hope to speak with any scientific accuracy of such things as "spawning beds," "nurseries," "feeding grounds," and the like.*

APPENDIX B.

FIRST LIST OF THE FISHES OF THE DISTRICT.*

Labrax lupus, Bass.

Mullus barbatus, Red Mullet.

Pagellus centrodontus, Sea Bream.

Sebastes norvegicus, Norway Haddock.

Cottus scorpius, Sea scorpion, Bullhead.

C. bubalis, Father Lasher, Bullhead.

Trigla cuculus, Red gurnard.

T. hirundo, Sapphirine gurnard.

T. gurnardus, Gray gurnard.

* From the Solway to the North Coast of Wales, and including the Isle of Man. Purely freshwater species not included. Drawn up by Mr. Corbin.

T. lineata, Streaked gurnard.
Agonus cataphractus, Pogge.
Lophius piscatorius, Sea devil or angler.
Trachinus draco, Weever.
T. vipera, Sting-fish.
Scomber scomber, Mackerel.
S. colias, Spanish Mackerel.
Orcynnus germo, Long finned Tunny.
Thynnus pelamys, Bonito.
Lampris luna, King fish.
Caranx trachurus, Horse Mackerel.
Zeus faber, John Dory.
Xiphias gladius, Sword fish.
Sciæna aquila, Shade fish.
Gobius niger, Goby.
G. minutus, Spotted Goby.
G. paganellus, Paganellus.
G. pictus, Goby.
G. ruthensparri, Double-spotted Goby.
Aphia pellucida, Nonnat (French).
Callionymus lyra, Dragonet.
Cyclopterus lumpus, Lumpsucker.
Liparis vulgaris, Sea snail or sucker.
L. montagui, Sea snail.
Lepadogaster bimaculatus, Two spotted sucker.
Blennius pholis, Shanny.
B. ocellaris, Butterfly Blenny.
Carelophus ascanii, Yarrell's Blenny.
Centronotus gunnellus, Butter fish.
Zoarces viviparus, Viviparous Blenny.
Mugil chelo, Lesser grey Mullet
Gasterosteus spinachia, 15-spined stickleback.
Labrus maculatus, Wrasse.
L. mixtus, Cook Wrasse.

Crenilabrus melops, The gilt head.
Ctenolabrus rupestris, Pink brame.
Gadus morrhua, Cod.
G. æglefinus, Haddock.
G. luscus, Whiting pout.
G. minutus, Poor Cod.
G. merlangus, Whiting.
G. virens, Coal fish or Saithe.
G. pollachius, Pollack.
Merluccius vulgaris, Hake.
Phycis blennoides, Forked Hake.
Molva vulgaris, Ling.
Motella mustela, Rockling.
M. tricirrata. 3 bearded Rockling.
M. cimbria, 5 bearded Rockling.
Raniceps raninus, Tommy noddy
Ammodytes lanceolatus, Greater sand Eel.
A. tobianus, Lesser sand Eel.
Hippoglossus vulgaris, Holibut.
Hippoglossoides limandoides, Long rough dab.
Rhombus maximus, Turbot.
R. lævis, Brett or Brill.
Zeugopterus punctatus, Müller's Top-knot.
Arnoglossus megastoma, Witch.
A. laterna, Scald fish or Megrim.
Pleuronectes platessa, Plaice.
P. microcephalus, Lemon Sole or Smear.
P. limanda, Dab or Gave.
P. flesus, Flounder.
Solea vulgaris, True Sole.
S. aurantiaca, Lemon Sole.
S. lutea, Solenette.
Maurolicus pennantii, Pearl sides.
Salmo salar, Salmon.

S. trutta, Sea trout.
Osmerus eperlanus, Smelt or Sparling.
Belone vulgaris, Garfish or greenbone.
Engraulis encrasicholus, Anchovy.
Clupea harengus, Herring.
C. sprattus, Sprat.
C. finta, Shad.
Anguilla vulgaris, Eel.
Conger vulgaris, Conger Eel.
Syngnathus acus, Pipe fish.
Nerophis æquoreus, Painted sea-adder.
N. ophidion, Straight nosed pipe fish.
Orthagoriscus mola, Sun-fish.
Acipenser sturio, Sturgeon.
Carcharias glaucus, Blue Shark.
Galeus vulgaris, Tope.
Mustelus vulgaris, Smooth hound.
Lamna cornubica, Porbeagle.
Alopias vulpes, Thresher.
Selache maxima, Basking Shark.
Scyllium canicula, Spotted dog fish.
S. catulus, nurse-hound.
Acanthias vulgaris, Picked dog fish.
Rhina squatina, Angel fish.
Torpedo nobiliana, Torpedo.
Raia batis, blue skate.
R. macrorhynchus, Flapper.
R. oxyrhynchus, Long nosed skate.
R. clavata, Thornback.
R. maculata, Spotted skate.
R. radiata, Starry ray.
R. circularis. Cuckoo ray.
Trygon pastinaca, Sting ray.
Petromyzon marinus, Sea Lamprey.
P. fluviatilis, Freshwater Lamprey.

[WORK FROM THE PORT ERIN BIOLOGICAL STATION.]

REPORT on the TURBELLARIA of the L.M.B.C. DISTRICT.

By F. W. Gamble, B.Sc.,
BERKELEY FELLOW OF THE OWENS COLLEGE, MANCHESTER.

With Plates XII to XIV.

[Read January 13th, 1893.]

The following Report is a summary of observations made during July and part of October, 1892, at the Port Erin Biological Station belonging to the Liverpool Marine Biology Committee. Owing to the limited time at my disposal much yet remains to be done before an accurate idea of the Turbellaria of the District can be formed. My researches at Port Erin and at the Marine Biological Association's Laboratory at Plymouth, seem to point to the conclusion that we are only beginning to ascertain the richness of this portion of the British Fauna. As a general result 28 species representing 23 genera have been found at Port Erin. Five of these are new to Britain.

The Turbellaria (like the Protozoa, Nematodes and some smaller groups) have, for various reasons been little studied in this country. It is chiefly to the following workers that the knowledge we possess of the marine species, is due.

Sir John Dalyell recorded a few species from the Firth of Forth; Dr. Johnson worked Berwick Bay; Mr. Wm. Thompson of Dublin worked the east coast of Ireland. In 1861 Prof. Ed. Claparède paid a visit to Skye, where he found many new forms. Prof. M'Intosh has noticed some species in his "Marine Invertebrates and Fishes of St. Andrews." These records, however, do not by any means give us a complete account of the Turbel-

larian fauna of the several districts. With the brilliant exception of Claparède's paper, the observations are frequently too fragmentary to allow us to accurately determine the species that are mentioned. A very valuable addition, therefore, to our knowledge is the description of 34 marine forms obtained by Professor von Graff during a two months stay at the "Ark" Millport, N.B. This list incorporated in his "Monograph" of the group (1882) furnishes a basis of comparison with other part of our coasts. For the last ten years, however, little work has been done on British Marine Turbellaria.

We may next consider how and where marine Turbellaria are to be found. Dividing the group for our present purposes into the flat leaf-like *Polyclads* 1 cm. or so long, and the small, usually cylindrical *Rhabdocœls* rarely more than 2 mm. in length, the following methods have proved successful. The Polyclads are to be found by extremely careful search on the under surface of weed-covered stones between tide-marks. Almost all forms are coloured in such a way as to remain unobserved unless the keenest vigilance be exercised. Infra-littoral species occur among shells, polyzoa and hydroids dredged at various depths up to 20 fms. The Rhabdocœles being minute cannot be directly observed on the shore. It is necessary to collect sea-weeds, stones covered with diatoms, ascidians, &c., the sand at the base of corallines, and to place these separately in vessels containing sea-water. The Turbellaria will presently emerge and can be found by searching the sides of the vessel with a hand-lens. Dredge-material treated in like fashion will yield numerous forms constituting a fauna fairly distinct from the littoral one. For Polyclads I have found the coast near Port St. Mary to be the best. For Rhabdocœles, the Calf Sound and tide-pools round Port Erin have proved most productive,

Pelagic Turbellaria are rare, but occasionally occur in tow-nettings. Such are certain Rhabdocœles and larval Polyclads.

TURBELLARIA.

I.—TRICLADIDA.

1. *Planaria alpina*, Dana (Pl. XII, figs. 1 and 2.)

This fresh-water species is about $\frac{1}{4}''$ in length, body grey, produced anteriorly into a pair of tentacles, a single pair of eyes are present. I have found it in cold springs near Silverdale (Lancashire) and in the sheltered gorges near Port Erin. This last fact taken in connection with Wm. Thompson's discovery of *alpina* on the East coast of Ireland (which however needs confirmation) have an important bearing on the geographical distribution of this Turbellarian. *Planaria alpina* is a distinctly alpine creature and where occurring at lower levels, does so in water of a constantly low temperature. Dana first found it in the Graubüntner Alps. It has since been found near Chur and in the Davos mountains at heights of 6—7000 feet and in water at a temperature of 2°C which is frozen from November to May. v. Kennel (in a most interesting paper, (Zoologische Jahrbücher, III, p. 447), to which I am greatly indebted) has found it in the Maine Valley at Würzburg at the outflow of a spring (temperature 10°C). The effect of a higher temperature than this is readily seen when attempts are made to keep these animals indoors. As soon as the water rises above 12°C they die very rapidly.

With these facts in mind v. Kennel has attempted their explanation. The difficulty is this, how did *Planaria alpina* get from Switzerland to Würzburg, England, the Isle of Man and Ireland? The tendency to explain this and similar cases by saying that *alpina* is a "Relickt-

form" of the ice-age, has induced von Kennel to oppose this easy method of solving the problem and to try whether recent migration of an active or passive nature may not sufficiently account for the facts. In the first plfice it is clear that (assuming recent migration) although active wandering may account for the occurrence of *Planaria alpina* in the Alps and in southern Germany, it cannot apply to England since, by hypothesis, England was separated by sea from the Continent. The only water-way from the Graubündtner Alps to the Maine Valley is the Rhine. Now although the water in the upper part of this river would be of a sufficiently low temperature to allow of *alpina* living in it, lower down the temperature is too high. If however, gradually from time to time, chiefly in the winter, migration had gone on extending further and further down the Rhine, suitable places might have been secured in the Maine Valley where the species might still be found. Such occurrences would scarcely have escaped the notice of the Germans, and as I said above, this reasoning cannot explain the presence of this form in countries separated by arms of the sea.

Next then, let us consider a passive migration. This is possible for fresh-water animals in two ways. (1) Winter eggs or eggs with resistant membranes might be carried by the wind to distant regions and (2) eggs or young may transferred by fish or birds, &c. *Planaria alpina* lays its eggs in capsules possessing chitinous walls. These capsules are attached to leaves or stones, and might be carried by the agencies I have mentioned. If either method were used we might expect to find this creature more generally distributed than is the case. It must however be remembered that it is only in certain places that the conditions are sufficiently favourable for existence. von Kennel gives an interesting example of this.

In a small pool near Würzburg, dry every summer, he finds Daphnids and Asplanchna. In another close by, Cypris, Culicidæ, and fly-larvæ, and these are never associated with Daphnids. When the conditions are favourable, development proceeds at a rapid rate. Thus in 1883 the summer was very dry in south Germany; no rain had fallen for weeks. One night a heavy thunderstorm broke and two days afterwards, v. Kennel found in rain-pools not only Infusoria, Ostracods, Mesostomid Turbellaria with winter-eggs, but also Branchipus with ripe eggs. The next day all was dry as before. How far passive migration has occurred in the case of *P. alpina* it is difficult to ascertain. At Würzburg, neither fish nor birds visit the spring where it is found. But this does not hold for other localities where I have seen it. If we keep in mind that it is at the point where springs reach the surface that this form chiefly occurs, it is not difficult to accept v. Kennel's supposition (before the eggs were known) that the real habitat of this animal is in the interior of mountains and in subterranean water and we are driven to the conclusion that the animal must have ranged over western Europe before the glacial epoch, acquiring its present distribution owing to the separation of England, Ireland and Isle of Man from the Continent and one another. Now however that the egg-capsules have been discovered, it appears more probable that a passive agency has been the main factor in a post-glacial process.

2. *Polycelis cornuta*, O. Schmidt (Pl. XII, fig. 5.)

This species occurs commonly in fresh-water in the neighbourhood of Port Erin, but in warmer water than *Planaria alpina*.

II.—RHABDOCŒLIDA.

A. ACŒLA:—This group is of considerable interest owing to the very simple organisation of its members. They have no alimentary canal or digestive cavity. The food (chiefly Entomostraca) is secured by the pharynx and passed on to the parenchyma which is the assimilating-tissue. An otolith is constantly present.

Family—APHANOSTOMIDÆ.

3. *Aphanostoma diversicolor*, Oe. (Pl. XII, figs. 6 and 7.) This species occurred in tide-pools close to the Port Erin Biological Station. It is distinguished by the colouration of the anterior end. The central part is violet, due to parenchymatous contractile pigment-cells; the peripheral portion and the extreme tip is coloured yellow owing to yellow vacuoles in the parenchyma. This form is recorded from Millport and Plymouth.

4. *Convoluta paradoxa*, Oe. (Pl. XII, fig. 3.)

During July, swarms of this species in different stages of development occurred among drift sea-weed (especially *Ceramia*) in Port Erin Bay. Tide-pools also yielded specimens but not so abundantly. The most interesting point of its structure is the presence of brown bodies usually known as yellow-cells or symbiotic algæ, which live in its tissue and largely determine its structure.

It has been known for ten years (owing to the work of Geddes and others) that another species of *Convoluta* (*C. schultzii*) contained chlorophyll, but whether the chlorophyll is autochromic, that is a product of the animal's activity; or exochromic, and due to symbiotic unicellular algæ, is a question which can scarcely be considered as thoroughly settled.

Geddes' attention was first drawn to these *Convoluta* when he saw what he took to be filamentous green sea-

weed lying in an inch or so of water in sandy tide-pools at Roscoff. The sea-weed upon examination proved to be a multitude of *Convoluta schultzii* which were basking in the sunlight in a most conspicuous way. Suspecting that this was a purposeful action, Geddes experimented and ascertained that the green bodies evolved oxygen and formed starch, while a most disagreeable odour (resembling that of trimethylamine) was exhaled, which probably rendered the animals free from attack and thus enabled them to enjoy the direct sunlight.

The green bodies consist of cells containing one or more chloroplasts, one or more pyrenoids, and rod-like masses of starch. In the present species (*C. paradoxa*) similar bodies but brown in colour are present. The physiological action of the brown bodies has not been tested. That of the green cells of *C. roscoffensis* has furnished the basis for recent work by Haberlandt* and his conclusion, if correct, in all probability will be found to apply to *C. paradoxa*. His hypothesis is to this effect. The green bodies are physiologically algæ, that is, are descended from algæ, "which at the present time owing to profound adaptation in and with the *Convoluta*, have lost their independent algal character and now constitute an integral histological element, the assimilating tissue of the *Convoluta*."†

Littoral species of animals adopt various devices in order to resist the attacks of the waves. *Convoluta paradoxa* adopts a method which, as Professor Herdman tells me, is paralleled in the Nudibranch *Ancula cristata*.‡ The "tail" or pointed hinder extremity of the body is provided with sticky adhesive papillæ which enable *C. paradoxa* to

* v. Graff, "Acœla," 1891.

† See Lankester "Nature," vol. XLIV., 1891, p. 465.

‡ See Trans. Biol. Soc., Vol. IV., p. 135.

remain firmly attached to its favourite weeds (species of *Ceramium*, &c.). These papillæ are elevations of the epidermis. The force of adhesion exercised by them, may be roughly estimated by using a powerful syringe. Repeated action of an in-going or out-going stream do not affect the Convoluta. It merely sways slightly in the direction of the current without in the least loosening its hold on the substratum. This device is general among littoral Turbellaria; some forms indeed (*Planaria dioica*, Claparède) are provided with adhesive papillæ over their entire surface.

Eggs of *Convoluta paradoxa* were found in orange clumps (30—40 in a clump) during July. Each egg measured ·07 mm. in diameter, and owed its colour to the contained food-yolk. The adult (physiologically a female) becomes a tense bag of eggs which ruptures at the slightest touch. Young *Convolutæ* swim with great ease and rapidity, resembling in colour, form, and movement, the Copepoda associated with them. They contain very few (4—8) zooxanthellæ and are consequently of a much lighter colour than the adults.

Convoluta paradoxa has been recorded from Firth of Forth, Berwick Bay, Guernsey, St. Andrews, Skye, Weymouth, Millport and Plymouth, and is generally distributed in northern and southern European seas.

5. *Convoluta flavibacillum*, Jensen (Pl. XII, fig. 4.)

Occurred in tide-pools in front of the Port Erin Station during July. It is distinguished from the preceding species by its larger, more robust form, and the absence of zooxanthellæ.

B. Rhabdocœla:—Family Mesostomidæ.

6. *Promesostoma marmoratum*, Schlz (Pl. XII, figs. 8, 9.)

This active littoral species appears to the naked eye as a fine whitish thread 1—1.5 mm. long. The body truncate

and furnished with adhesive papillæ posteriorly, tapers gradually forwards from the hinder fourth of its length. Reticular black pigment was present only between the eyes. The character which especially distinguishes this species is the copulatory organ (fig. 9). This consists of a fine chitinous tube coiled in the manner of a bishop's crozier. This tube is enclosed in an outer muscular one which transmits the spermatozoa, the inner chitinous duct containing the secretion of the accessory or granule-gland.

The form of the copulatory-organ among Turbellaria has been much used for the discrimination and determination of species in this group. It is therefore interesting to find in different individuals of *Promesostoma marmoratum*, an amount of variation of this organ, which, unless intermediate forms occurred, would certainly rank them as different species. Thus only one loose turn of the spiral may be present, and the form of the apex may vary considerably from that seen in fig. 9. This fact appears to be correlated in some way with the wide geographical distribution of the species, which ranges from the west coast of Greenland to the Mediterranean and Black Sea. This species has occurred at Skye, Millport, and Plymouth. At Port Erin it occurs in tide-pools.

7. *Promesostoma ovoideum*, Schm. (Pl. XII figs. 10, 12.)

A pale specimen of this species (wanting the usual black reticular pigment) occurred among shell-dèbris dredged outside Port Erin Breakwater, October, 1892, and is new to the British fauna. After leaving Port Erin I found it under similar conditions at Plymouth.

8. *Promesostoma lenticulatum*, Schm. (Pl. XII, figs. 11, 13.)

This species, hitherto only seen by Schmidt who found it at the Faroe Islands, occurred among *Corallina* in a tide-pool near the Port Erin Station.

Schmidt's description did not include the genital organs, and since these afford the most distinctive features, the systematic position of this species has long been doubtful. Length .65 mm. Body truncate and slightly convex in front with rounded projecting angles. Colour bright red, due to the contents of the gut. The eyes are very striking owing to the comparatively large size of the lens. The pharynx is sub-central. The copulatory organ has the form of the tool known as a "rose-bit" or "countersink." For further description of this and other species included in this paper, see my memoir on "British Marine Turbellaria," in the forthcoming number of the "Quarterly Journal of Microscopical Science."

9. *Byrsophlebs intermedia*, v. Graff (Pl. XII, figs. 17, 18.) Length ·5 mm. Body flattened, yellowish-white, rounded in front, bluntly pointed behind. The feature which distinguishes this species from the closely allied *B. graffi*, Jensen, is the elongate form of the penis, the basal part of which is composed of the granule-vesicle strengthened by spiral muscles. The distal part is enclosed in a funnel-shaped copulatory-organ ending in a rounded aperture, from the margin of which a chitinous spur is given off.

This species occurred along with *Provortex balticus* and other forms in a coralline tide-pool near the Biological Station, Port Erin.

10. *Proxenetes flabellifer*, Jens. (Pl. XII, figs. 14, 15, 16.) This species has the form of a fine white thread the advancing end of which is kept in continual, sensitive motion above the substratum. The hinder end is provided with well-developed adhesive papillæ which are speedily used at the slightest provocation. The rhabdites are present in large numbers in this genus, forming a pair of extensive and well-marked tracts converging between the eyes to the anterior end. The copulatory-organ is retort-

shaped, and consists of a number of chitinous pieces, separating the duct of the vesicula seminalis from the passages constituting the outlets for the granule-gland. The sperm, conveyed down the main duct, issues through the passages‡ ‡ ‡, the granule-secretion on the other hand by the duct marked ‡ ‡, outside the retort. The chitinous strips forming the neck, are bound together by the piece marked D. The spermatheca, placed in front of the genital pore, receives at its blind end the chitinized ducts of an accessory-gland, while its distal portion bears a series of five triangular chitinous teeth hinged at their bases to its inner wall.

This species occurred in tide-pools round Port Erin and also commonly among weeds from "the Clets" a group of rocks in the Calf Sound. It has been recorded from Millport and Plymouth.

Family—Proboscidæ.

11. *Pseudorhynchus bifidus*, M'Int. (Pl. XIV, figs. 33, 34.)

Length 1 mm. Body produced in front into a conical non-ciliated "proboscis"; posteriorly it widens and ends in a bifid hinder extremity. Colour whitish-yellow with rounded brown spots over the surface. This form is interesting as it shows the way in which the proboscis characteristic of this Family has been elaborated. In *Pseudorhynchus* the proboscis is simply the slightly modified anterior extremity, furnished with numerous short retractor muscles. It is probable that by a specialization of these together with the addition of a mass of muscles known as the "muscle-cone" and a pharyngeal sheath, the typical proboscis has been formed as we see it in *e.g. Acrorhynchus*.

The copulatory-organ is a long funnel-shaped chitinous structure, round the outer face of which a spiral ridge

occurs, produced at regular intervals into spinous processes. The use of this organ has not been definitely ascertained. It appears possible that it may have some use as an offensive weapon. It this connection another member of this family, *Gyrator hermaphroditus,* (found in fresh-and sea-water in this country) is suggestive. The so-called copulatory-organ is here converted into a stylet enclosed in a sheath and provided with protractor and retractor muscles. According to Hallez, it plays no part in copulation but enables the animal to seize the Entomostraca upon which it feeds. On approaching one of these, *Gyrator* bends the hinder end of the body (containing the stylet) downwards and forwards and stabs its prey repeatedly, which is then taken up by the pharynx.

Pseudorhynchus bifidus occurred among drift-weed in Port Erin Bay. It is also recorded from St. Andrews where it was first discovered by Prof. M'Intosh; and from Millport.

12. *Acrorhynchus caledonicus*,Clap.(Pl.XIII,figs.19,20.)

Length 1 mm. Body elongate, cylindrical, slightly tapering anteriorly. Colour white with grey blotches, the pharynx pure white. The dermal musculature, as in most representatives of this family, is very strong, and enables the animal to bear compression under a cover-slip without rupture. A mature animal treated in this way displays the complicated reproductive organs with almost diagrammatic clearness. The granule-and sperm-vesicles are bound together in a common penial muscular sheath which leads into a copulatory organ armed with small knobbed chitinous spines.

This form is frequently obtained among sea-weeds between tide-marks at Port Erin, and also occurs at Skye, Millport, and Plymouth.

13. *Macrorhynchus naegelii*, Kölliker. (Pl. XIII, fig. 21.)

In form, colour and size this species closely resembles the foregoing. It may be readily distinguished, however, by the presence of a special chitinous investment round the lower portion of the granule-vesicle. This is a short funnel-shaped tube, the wide mouth of which is usually provided with a curved spur.

The great bulk of the genital organs in this and other species of Proboscidæ, leads, during the development of the individual, to the loss of the alimentary canal as a definite coherent structure. Consequently, examination of adults shews that the body is almost exclusively filled with the reproductive apparatus, the gut being merely represented by isolated cells.

This species occurs at Port Erin, Millport, and Plymouth.

14. *Macrorhynchus helgolandicus*, Met. (Pl. XIII, fig. 22.)

During my visit to the Port Erin Station, during October of last year I found a number of immature examples of this form which is distinguished from all other species of *Macrorhynchus* by the possession of a special "poison-dart" in addition to complicated male and female copulatory organs. This had led v. Graff to place this species in a special division "Venenosi" as opposed the remaining Macrorhynchus-species included as "Typici."

M. helgolandicus has also occurred at Millport and Plymouth.

15. *Hyporhynchus armatus*, Jens. (Pl. XIII, figs. 23, 24.)

Length 1 mm. Body very elongate, thread-like and of a white colour. Although usually associated with other Turbellaria of a similar colour and appearance, this species is distinguished (as they are in turn) by peculiarities of locomotion which are sufficient to enable one to identify it even with the naked eye. The proboscis (as in

the sub-family Hyporhynchinæ) opens on the ventral surface, behind the anterior extremity, and is much reduced in size as compared with that of the Acrorhynchinæ. The copulatory-organ consists of two spirally-coiled chitinous tubes fused throughout the greater portion of their lengths. Of these the finer duct transmits the granule-secretion, the wider one enables the spermatozoa to reach the exterior. The spiral takes two complete turns and ends in a terminal straight portion where the two ducts separate from one another.

This species was dredged in 15 fms. just outside Port Erin Breakwater. It has also occurred at Plymouth.

Family—VORTICIDÆ.

16. *Provortex balticus*, Schultze (Pl. XIII, figs. 27, 28.)

Length ·5—·75 mm. Body cylindrical, truncated, in the angles produced into blunt processes. The posterior extremity forms a long, finely-pointed "tail." The colour is due to irregular brown pigment which appears to be deposited as fine vacuoles in the cells of the parenchyma· The pharynx which opens through the mouth just below the anterior end, is provided with a distinct "seam" to to the margin, furnishing a surface of insertion for the strong pharyngeal retractor muscles.

The copulatory organ is cylindrical. Its aperture constitutes a slit, one margin of which is bent upon the main-duct and ends in a free process of variable shape. The uterus discovered by von Graff, lies in front of the penis and contains a single yellow cocoon at a time. A long fine duct leads to the genital aperture.

This extremely active, tiny animal occurs plentifully in tide-pools near the Port Erin Station. It is also recorded from Millport and Plymouth.

C. Allœocoela : Family—Plagiostomidæ.

17. *Plagiostoma sulphureum*, v. Gr. (Pl. XIII, figs. 29,30.)

Length 2 mm. Body elongate, cylindrical, slightly narrowed and rounded at both extremities. Colour bright yellow, due to the rhabdites which lie in the epidermis. The mouth and the very small pharynx lie just behind the brain. The intestine occupies the central part of the length of the body. Opening into the pharynx is a large number of pyriform, finely granular cells, apparently glandular. Behind these a mass of cells occurs from which the ova develope from before backwards. A pair of vitellaria lie at the sides of the body, uniting in front. The follicular testes, few in number, are sub-central. The penis consists of a large proximal vesicula seminalis and a terminal muscular tube enclosed in a sheath. The spermatozoa, which afford the safest mark by which this species may be recognised, have a broad central portion, a finely-tapering tail and a cap-like anterior end. These are lateral expansions of the fine, sinuous central thread.

It is interesting to find this species, hitherto only recorded from Trieste, in a coralline tide-pool near the Port Erin Biological Station.

18. *Plagiostoma vittatum*, Frey & Leuck. (Pl. XIII, fig. 26.)

Length 1—2 mm. Body rounded in front, tapering gradually posteriorly. The colour is usually in the form of three transverse bands of purple reticular pigment; one across the head, another across the centre of the body, and a third across the tail. This is the typical form, but varieties are almost as abundant as the type. Thus von Graff at a single haul among Ulva, at Millport, obtained nine colour varieties.

The cocoons of this species occur in the autumn. They are brown, stalked vesicles, which according to van Beneden are attached to the abdominal appendages of the

lobster, but I have found them on the surface of weed-covered stones between tide-marks.

This species is not uncommon in tide-pools at Port Erin, and is abundant at Millport and Plymouth. Young specimens occur in tow-nettings taken near shore.

19. *Vorticeros auriculatum*, O.F. Müller (Pl. XIII. fig. 25.)

Length 1·5—2 mm. Body elongate. The angles of the anterior margin are produced, in the expanded condition, into a pair of slender tentacles, almost $^1/_5$ the length of the body. They may, however, completely disappear during contraction. The colour is due to violet, reticular, parenchymatous pigment which occupies the dorsal surface (except the margins) and is continued as a narrow band over the upper surface of the tentacles. The anatomy resembles in detail that characteristic of *Plagiostoma*.

This elegant form occurs in tide-pools at Port Erin. It has been taken by v. Graff at Millport, and myself at Plymouth.

20. *Allostoma pallidum*, P.J. v. Ben. (Pl. XIII, figs. 31, 32.)

A few immature examples of this species occured at Port Erin. The anterior sixth is marked off from the rest of the body by a circular ciliated groove. The epidermis contains large numbers of "mucus-rods," which have been considered as intermediate between the amorphous secretion of a subepidermal gland, and the sharply-defined rhabdites. All three are homologous, but differ in the degree of consistency.

The common genital pore is almost terminal at the hinder end. The penis is muscular. It receives the vasa deferentia and granule-gland in its upper proximal portion. The oviducts (according to v. Graff), unite before opening to the exterior. This species has been recorded from Millport.

21. *Cylindrostoma quadrioculatum,* Leuck. (Pl. XIV. figs. 35 and 36.)

Length ·5—·75 mm. Body colourless, rounded in front, produced posteriorly into a long pointed "tail," beset with adhesive papillæ. The pharnyx and its large cylindrical sheath are long and muscular. The mouth is placed just in front of the brain, The latter is quadrate, and bears two pairs of eyes: an anterior small pair, the lenses of which are directed backwards and outwards, and a larger posterior pair, whose lenses face forwards and outwards. The sides of the body are occupied by a large gland, which produces food-yolk throughout its anterior portion, ova in the posterior. Hence it is called the germ-yolk-gland. The genital aperture is combined with the mouth, and through it the muscular penis containing both male secretions opens to the exterior. A large spermatheca lies at the hinder end of the body.

Cylindrostoma quadrioculatum occurs in tide-pools at the base of the littoral zone, near Port Erin. It is also recorded from Millport, Skye, and Plymouth.

22. *Cylindrostoma inerme,* (Hallez.)

This species resembles the former in many points, but is distinguishable from it by the following characters. The form of the body is stouter, the tail shorter. The bright yellow colour is due to small groups of pigment granules in the epidermis. The genital organs in general correspond closely to those of the foregoing species, but a spermatheca is absent. This form occurs among drift seaweed in Port Erin Bay and is also found at Plymouth.

Family—MONOTIDÆ.

23. *Monotus lineatus,* O. F. Müller, (Pl. XIV. fig. 39.)

Length 2—2·5 mm. Body elongated, flattened, tapering anteriorly, armed with strong adhesive-cells posteriorly.

The colour is white, frequently marked with brown pigment. The epidermis contains numerous flagella. The anterior end is used in an extremely sensitive way. Immediately upon encountering any obstacle it is sharply retracted, and the hinder extremity at the same moment grasps the substratum by its shield-shaped adhesive surface. This is done so rapidly that it becomes difficult to surprise the animal and capture it by means of a pipette.

A short distance from the anterior end an otolith is constantly present in members of this family, and in front of it is a median transverse band of pigment usually spoken of as the "eye." The pharynx is inserted near the centre of the body, and is extremely contractile. The germaria, two in number, are placed at the sides of the base of the pharynx. The penis is characteristic of the species. It is merely a soft papilla receiving the contents of the muscular vesicula seminalis, and transmitting them to the exterior through the male pore, which is placed behind the female pore, a short distance from the posterior end. *Monotus lineatus* occurs not uncommonly among *Corallina* in tide-pools about Port Erin and on the "Clets." It is recorded from Millport, Skye, St Andrews, and Plymouth.

24. *Monotus fuscus*, Oersted. (Pl. XIV, figs. 37 and 38.)

This species resembles the former in many external and internal anatomical features. The colour however is rather different. The anterior end is whitish, the rest of the body brown. Von Graff and Jensen record individuals with purple pigment.

The changes of colour undergone by young *Monotus* in reaching the adult condition are the following, as v. Graff has already noticed. Very young specimens (1 mm. or so,) are white, with a few carmine granules. Next, these granules increase in number, giving a reddish tint

to the individual. Lastly, the red colour of the granule gives way to brown which appears when the specimens reach 1·75—2 mm. in length.

Monotus fuscus ranges through the littoral zone to its higher portions where the rocks and weeds are exposed to the drying effects of the atmosphere. Turbellaria are however so constituted (being without any outer protective membrane) that dryness means death to them. It is interesting therefore to find *M. fuscus* adopting a singular device in order to gain a moist environment during the ebb-tide. Prof. Hallez, of Lille, in 1879, recorded that after scraping *Balani* off the rocks at Wimereux, and placing them in a basin of sea-water, this form presently emerged. They had concealed themselves among the thoracic appendages of the *Balani*, and thus continued to keep their surface in contact with a moist medium. Hallez hence called it *Monocelis balani*. Prof. v. Graff has found that at low water *M. fuscus* occurs between the gills of Chiton and Patella, and he supposes that it leaves this situation when the tide returns. *Balanus balanoides* at Port Erin yielded several specimens. The copulatory organ has the form of a tubular chitinous duct, attached by muscles to the mouth of the vesicula seminalis.

Monotus fuscus occurs between tide-marks at Port Erin, Millport, and Plymouth.

III. POLYCLADIDA.

A. ACOTYLEA: Family—LEPTOPLANIDÆ.

24. *Leptoplana tremellaris*, O. F. Müll. (Pl. XIV, fig. 40.)

Length 20—25 mm. Body delicate, slightly expanded in front, the anterior margin being almost semi-circular. Swimming is effected by repeated violent vertical strokes of the expanded margins. The colour is variable. White,

light-brown, and mottled dark-brown specimens occur. On the ventral surface the central, plaited pharynx is readily seen lying in its sheath. Behind it comes the male genital pore, towards which the conspicuous V—shaped area, caused by the vasa deferentia, converges: behind this again, the female pore. Behind these two apertures is a muscular depression, the sucker, which is probably of considerable use to the animal since it ensures a firm hold on the substratum. From the dorsal surface the sacculated main-gut and its numerous lateral branches may usually be seen. In front, four groups of eyes are generally readily distinguishable although occasionally the two groups on each side unite, so that their double nature is not obvious. The anterior group consists of eyes which, in genera closely allied to *Leptoplana*, surround the bases of a pair of tentacles, hence the term *tentacular group*. The tentacles persist in a rudimentary condition in *L. Alcinoi*, Lang. The posterior group contains rather larger, more markedly reniform eye-specks. From other species of *Leptoplana* which resemble *tremellaris* in appearance, this species may be distinguished by the presence of the sucker and by the simple, non-muscular, female genital canal.

This species occurs at Hilbre Island, Puffin Island, Port Erin, and Port St. Mary, on the under surface of weed-covered stones between tide-marks. It also descends to about 20 fms. Young specimens are more or less pelagic and differ from the adult in their shape which is almost that of a spherical triangle.

Other localities for *L. tremellaris* on the British coast are the following:—Firth of Forth, St. Andrews, east coast of Ireland, Aberystwyth and Plymouth.

B. Cotylea: Family—Euryleptidæ.

25. *Cycloporus papillosus*, Lang. (Pl. XIV, figs. 41, 44.)

Length 10—15 mm. Body fairly consistent, oval, slightly narrowed in front, where it is continued into a pair of short stumpy tentacles. The dorsal surface is typically produced into a number of small, usually brightly coloured papillæ which are quite superficial elevations and do not involve the underlying alimentary canal. They are absent in the variety *laevigatus*, and are replaced by pigment-spots. The colour is very variable and the meaning of this variability is discussed below. Peripheral clumps of pigment occur on the margin. Eyes are present on and round the bases of the tentacles, and a pair of larger groups are also present over the brain, (cephalic groups). The mouth lies behind the brain and leads into a bell-shaped pharynx which appears as a light area on the dorsal surface. The long main-gut is median and gives off 6—7 pairs of lateral branches. The male and female genital aperture lie behind the mouth in the order named. The sucker is subcentrally placed on the ventral surface of this animal.

The conditions under which *Cycloporus* is found appear to point very forcibly to the conclusion that the colouring is associated and probably correlated with that of the substratum. *Cycloporus* is found often in pairs of similarly coloured individuals, on the surface of sponges and compound ascidians both in the littoral and deeper zones. The general colour is frequently but not always that of the particular ascidian (*Leptoclinum durum*, &c.) The main-gut which is median with lateral branches, appears to simulate lines separating off the cœnobia, while the peripheral pigment-spots resemble in detail the coloured and expanded ends of the vessels of the ascidian test. This is not all. The sucker with which the *Cycloporus* is provided,

enables it to adhere so strongly to the substratum of which it appears to form an integral part, that it is often necessary to use a knife to detach the specimens. Professor Lang has observed numerous examples at Naples and these appear to be adapted each to its particular and self-coloured surroundings.

While these facts, the striking nature of which can only be realised on the shore, appear to point to detailed adaptation in the form, texture, colour, and immobility of the Polyclad to the Ascidian, there are one or two opposing facts which must not be omitted in attempting to arrive at a just conclusion. *Cycloporus* is sometimes found on substrata, with which it has no perceptible resemblance and secondly 3—5 black spots are generally present in var. *laevigatus* which have no analogue in the ascidian. This only helps to shew how very fragmentary and incomplete is our knowledge of the true life-relations of these animals. A theory, thoroughly consistent with the facts cannot be framed until far more observations than we at present possess, are made in different localities and at different times of the year.

Certain colour-varieties of *Cycloporus papillosus* closely resemble *Stylostomum variabile,* and it may be useful to point out the features by which the former can be always recognized. The presence of a median gut-branch over the pharyngeal region is diagnostic. Such a branch only exists *in front* of that region in *Stylostomum.* Again, examination of living or still better, of well-preserved specimens of *Cycloporus,* shews that the mouth-opening is distinct from the male and female genital apertures. In *Stylostomum* on the other hand, the male and oral apertures are united and open just behind the brain.

Cycloporus papillosus has been observed by Prof. Herdman at Puffin Island, and was dredged by Mr. H.

C. Chadwick, in 12 fms., off Bradda Head, Port Erin. The variety *laevigatus* has been taken by Mr. W. J. Beaumont and myself, between tide-marks, both at Port Erin and Port St. Mary. I have also taken it at Plymouth.

26. *Oligocladus sanguinolentus*, Quatr. (Pl. XIV, fig. 42, 45.)

Length 6—7 mm. Body elongated, oval, broadly rounded behind, slightly narrowed in front. A pair of long, conical marginal tentacles are present, and between them the anterior extremity projects slightly. Ground-colour white, against which the deep carmine-coloured intestine is distinctly visible. The mouth is far forward, in front of the brain. The strong muscular cylindrical pharynx, is enclosed in a sheath which gives off a posterior coecum extending behind the mid-ventral sucker. 4—5 pairs of secondary branches arise from the straight main-gut. The first pair enclose the pharynx and unite in front of it. From this junction a short median offset represents the unpaired branch which in other Polyclads arises directly from the main-gut. A terminal gut-branch enters each tentacle. Eyes are present round the bases of the tentacles and also as a couple of small sharply-defined groups over the brain. The male genital aperture lies just behind the brain. The female pore surrounded by the radiating masses of the "shell-gland," is placed half-way between the male pore and the mouth.

This species, hitherto only recorded by Köhler, from Guernsey,* was dredged on several occasions among shell-dèbris outside Port Erin Breakwater. I have also found it under similar conditions at Plymouth.

Eurylepta cornuta which probably occurs, though I have not met with it, in the L.M.B.C. district, differs from this species by its large size (sometimes an inch long), scarlet colour, and elongate group of eyes over the white pharynx.

*Annals & Mag. Nat. Hist., XVIII, 1886.

27. *Stylostomum variabile*, Lang (Pl. XIV, figs. 43, 46.)

Length 5—8 mm. Body oval, rounded posteriorly, narrowed anteriorly. The angles of the truncated front-margin are slightly produced into rudimentary tentacles. The body is usually colourless, and is more or less transparent according as the genital organs are less or more developed. Immature examples display the branches of the brightly-coloured intestine very clearly.. The mouth combined with the male genital pore, is just behind the brain. The muscular pharynx gives rise to the white anterior area seen upon the dorsal surface. Small groups of eyes are present over the brain, and at the base of the tentacles. In front of the sucker lies the female pore, surrounded by the massive "shell-gland." The uterus is placed at the sides of the main-gut.

This species was dredged on shelly ground, outside Port Erin Harbour. It also is found at Plymouth, and has been recorded by Dalyell from the Firth of Forth.

In concluding this Report I wish to express my hearty thanks to Prof. Herdman for the use of the L.M.B.C. Station, at Port Erin, and to my friend Mr. W. J. Beaumont, for his ever ready assistance in the capture of these Turbellaria.

Explanation of Plates, XII—XIV.

List of Abbreviations :—

AU eyes, BR brain, CH copulatory organ, D intestine, DP dorsal papillæ, EJ ejaculatory duct G and PE penis, GA genital atrium, GD poison glands, GER germaria, GO genital aperture, KC chitinous granule-duct,

KD granule-gland, ME penial sheath, MO mouth, MR retractor muscle, OD oviduct, OT otolith, PH pharynx, PR proboscis, PS penis-sheath, RS receptaculum seminis, T testis, TE tentacle, S stylet, SB and VS vesicula seminalis, SK sucker, SP spermatozoa, ST chitinous investment of ejaculatory duct, SP spur of copulatory organ, TR investment around vesicula, UT uterus, VD vas deferens, VG vesicula granulorum, X muscular pit.

Plate XII.

Fig. 1. *Planaria alpina*, Dana. Drawn from the living animal. Natural length ·75—1·5 cm. (× 2).

Fig. 2. *Planaria alpina*, Dana. The genital atrium and organs in connection with it.

Fig. 3. *Convoluta paradoxa*, Oe. From the living animal, seen from the ventral surface. Natural length 2 mm. (× 20).

Fig, 4. *Convoluta flavibacillum*, Jensen. (Partly after v. Graff), (× 15).

Fig. 5. *Polycelis cornuta*, O. Schmidt. Anterior part of body (× 15).

Fig. 6. Violet pigment-corpuscles from *Aphanostoma diversicolor*, Oe.

Fig. 7. *Aphanostoma diversicolor*, Œrsted (× 30).

Fig. 8. *Promesostoma marmoratum*, Schultze (× 25).

Fig. 9. The copulatory organ of *P. marmoratum.*

Fig. 10. *Promesostoma ovoideum*, O. Schmidt (× 40).

Fig. 11. *Promesostoma lenticulatum*, O. Schmidt (× 40).

Fig. 12. Copulatory organ of *P. ovoideum.*

Fig. 13. Copulatory organ of *P. lenticulatum.*

Fig. 14. *Proxenetes flabellifer*, Jensen. Natural length 1·75 mm. (× 20).

Fig. 15. Chitinous teeth from the duct of the spermatheca of *P. flabellifer.*

Fig. 16. Copulatory organ of *P. flabellifer*, (after v. Graff).

Fig. 17. *Byrsophlebs intermedia*, v. Graff. Natural length 1 mm. (× 20).

Fig. 18. Copulatory organ of *B. intermedia*.

Plate XIII.

Fig. 19. *Acrorhynchus caledonicus*, Claparède. Drawn from the living animal. Natural length 1·5—2 mm. (× 20).

Fig. 20. Copulatory organ of *A. caledonicus*.

Fig. 21. Granule-vesicle of *Macrorhynchus naegelii*, Köll.

Fig. 22. Male genital organs of *Macrorhynchus helgolandicus*, Metschnikoff, (after v. Graff).

Fig. 23. *Hyporhynchus armatus*, Jensen. Natural length 1·5 mm. (× 25).

Fig. 24. Copulatory organ of *H. armatus*.

Fig. 25. *Vorticeros auriculatum*, O.F.M. Tentacles not quite fully extended. Drawn from life (× 25).

Fig. 26. *Plagiostoma vittatum*, Frey and Leuckart (× 25).

Fig. 27. *Provortex balticus*, Schultze. From the living animal (× 60).

Fig. 28. Chitinous copulatory organ of *P. balticus*.

Fig. 29. *Plagiostoma sulphureum*, v. Graff. From the living animal. Natural length 2 mm. (× 25).

Fig. 30. Ripe spermatozoon of *P. sulphureum*.

Fig. 31. *Allostoma pallidum*, van Beneden. Natural length 1·5—2·5 mm. (× 25).

Fig. 32. The genital organs of *A. pallidum*, (after v. Graff).

Plate XIV.

Fig. 33. *Pseudorhynchus bifidus*, M'Intosh. Drawn from life, showing the anterior conical proboscis. Natural length 1·5 mm. (× 25).

Fig. 34. Corkscrew-shaped copulatory organ of *P. bifidus*, (after v. Graff).

Fig. 35. *Cylindrostoma quadrioculatum*, Leuckart.

Fig. 36. Head of *C. quadrioculatum*,

Fig. 37. *Monotus fuscus*, Œrsted. (The figure also represents *M. lineatus*.) From the living animal.

Fig. 38. Copulatory organ of *M. fuscus*.

Fig. 39. Copulatory organ of *M. lineatus*.

Fig. 40. *Leptoplana tremellaris*, O.F.M. From the living compressed animal, ventral surface. Natural length 18 mm. (× 2).

Fig. 41. *Cycloporus papillosus*, Lang. (× 8).

Fig. 42. *Oligocladus sanguinolentus*, Lang. Length 1·1 cm. (×4).

Fig. 43. *Stylostomum variabile*, Lang. An immature specimen (× 5).

Figs. 44—46. Diagrams to illustrate the relation positions of mouth and genital aperatures, and other points which distinguish the genera *Cycloporus*, *Oligocladus* and *Stylostomum*, (after Lang).

[WORK FROM THE PORT ERIN BIOLOGICAL STATION.]

REVISED REPORT on the COPEPODA of LIVERPOOL BAY.

By Isaac C. Thompson, F.L.S., F.R.M.S.

With Plates XV to XXXV.

[Read February 10th, 1893.]

Three previous Reports have been issued upon the Copepoda of the L.M.B.C. District, the last being in the year 1889. Since that time so many species new to the district have been found that it was thought advisable to draw up a complete Report of all the species recorded in the district up to the present time.

Previous to the work of the L.M.B.C., commenced in 1885, very little in this group had been done, six species only of marine Copepoda having been recorded in our area. The present Report deals with 136 species of which 18 are new to British seas, 11 of them being new to science. Those new to British seas are as follows:—

Labidocera acutum, Dana, *Euchæta marina*, Prestandrea, *Giardella callianassæ*, Canu, *Monstrilla danæ*, Claparède, *Monstrilla rigida*, Thompson, *Sabelliphilus sarsii*, Claparède, and *Artotrogus orbicularis*, Boeck. Those new to science are:—

Herdmania stylifera, Cyclops marinus, Hersiliodes puffini, Jonesiella hyænæ, Ameira attenuata, Stenhelia denticulata, Stenhelia hirsuta, Monstrilla longicornis, Laophonte spinosa, Cletodes monensis, and *Lichomolgus maximus*.

The total number 136 species are divided amongst the various families as follows: Calanidæ 13 species, Pontellidæ 4, Misophridæ 3, Cyclopidæ 7, Notodelphidæ 7, Harpacticidæ 72, Monstrillidæ 4, Sapphirinidæ 11, Arto-

trogidæ 6, Chondrocanthidæ 1, Caligidæ 6, Lernæidæ 1, and Lernæopodidæ 1 species.

It will be noticed that the above enumeration includes both the free swimming and semi-parasitic and wholly parasitic species, any exact line of division being impracticable as many of the semi-parasitic species are free swimmers at night being also occasionally taken by townet during the day. This is especially the case with members of the family Caligidæ.

During the many expeditions in the "Hyæna," "Spindrift," "Mallard" and other vessels, townets at the surface and at various depths have been systematically employed; and washings from dredged material have often yielded good results. The establishment of the Marine Biological Station upon Puffin Island early on in our work, under the directorship of Professor Herdman, F.R.S., proved of the greatest service as regards the investigation of Copepoda, for besides affording the opportunity of frequent personal visits, the resident curator during the greater part of the time forwarded regularly townettings, dredged mud, &c., for examination taken at various hours day and night and throughout the entire year. After five years work at Puffin Island, the removal of the L.M.B.C. Station to Port Erin at the south-west corner of the Isle of Man in the summer of last year has proved a complete success. The accessibility of the new station and its more completely equipped laboratory have facilitated the ready examination of living specimens immediately on landing from the boats, a circumstance of great value when dealing with minute forms of life like the Copepoda subject to rapid decomposition.

The muddy bottom of Port Erin Bay inside the breakwater has proved an exceedingly rich hunting ground for Copepoda, several of the new species having been taken

there as well as several rare ones not taken in any other part of the district. Indeed it seems probable that it is from dredged material in such localities that we must look chiefly for additions to our microscopical fauna, the free swimming forms of our district being more completely tabulated.

Experience further leads me to the opinion that small isolated tracts, probably local depressions in a muddy or sandy bottom are particularly rich in Copepoda, apparently similar material taken from near such local centres having at the same time proved most unprolific or nearly altogether destitute of life. The rock pools at Hilbre Island as well as those of Puffin Island have proved valuable hunting grounds worked with a fine hand townet.

The parasitic species in the Report found in the branchial sacs of Ascidians have all been sent to me by Prof. Herdman. To him also and to his "Fisheries Laboratory" Assistant Mr. P. J. F. Corbin I am indebted for a large number though hitherto not a great variety, of fish parasites. The recent establishment of this Fisheries Laboratory gives promise of much valuable opportunity for the study of this important and rather neglected branch of our Copepodan fauna. Many of the other fish parasites here recorded were collected by our lamented colleague Mr. Frank Archer, B.A., while staying at Bull Bay, Anglesey.

A new form of *Lichomolgus, L. agilis,* has been recently described by Mr. Thomas Scott, F.L.S., of the Scottish Fishery Board, from specimens inhabiting the inside of Cockle shells. This species I have found in the water of all the fresh cockles examined and it is probably very common, although previously overlooked. I had, however, taken it two years ago in a night townetting off Puffin Island, and put it aside as a new form, but deferred any

description in the hope of finding more specimens. Still more recently I have found in the shells of the *Pecten maximus* a large *Lichomolgus* herein described as *Lichomolgus maximus.* It is probable that the examination of other mollusca obtained when dredging may lead to the discovery of further new species of parasitic Copepoda. A closely allied species to the two last mentioned, *Sabelliphilus sarsii*, Claparède, was sent to me by Mr. Chadwick, adherent to the tentacles of a species of *Sabella* collected on the Beaumaris shore. I have since found it attached to the same host around Puffin Island and think it probable that although apparently hitherto unrecorded elsewhere in British waters, it only requires looking for.

As a preservative fluid for Copepoda I have always found a mixture composed of equal parts of Alcohol, Water and Glycerine with 1 per cent. of Carbolic Acid most useful. Specimens may be transferred direct to it from sea water and can be so preserved for any desired period of time, to be mounted direct without further preparation in either Glycerine Jelly or Farrants Medium. I can confirm the value of Canon Norman's "excellent device" for capturing Copepoda and other small Crustacea while alive from freshly dredged material as given by Mr. A. O. Walker, F.L.S. (Report on the Higher Crustacea of Liverpool Bay taken in 1889) Fauna of Liverpool Bay, Report III, p. 239, 1892, many rare Copepoda having come to me through this means. Recently I have employed a still more exhaustive method with the greatest advantage, particularly when as is often the case material or dredged mud or sand requires to be kept a considerable time before it can be examined, viz., the dredged material is washed through a coarse sieve into a finely meshed silk bag into which a running stream of water from a tap is allowed to fall. By careful kneading with the hands

all the soluble or very finely suspended particles are washed away through the texture of the bag. The clean residue is then placed in a large flat dish of water and stirred round, when the fine floating organic portion, often very rich in Foraminifera, Diatomacea, Ostracoda, Amphipoda, and Copepoda can be strained off and placed in preservative fluid for examination.

As a ready means of detecting and naming species must be of value to the sea side naturalist, I have in the plates (XV to XXXV) given small outline sketches of the forms treated of in this Report together with reference to special points of distinction so far as space allowed. They are mostly taken direct from the animal under the microscope, a few being taken in part from the drawings of Claus, Brady, &c. In the cases of genera including several species, the distinctive points only of some are given.

The importance to man of the distribution of Copepoda in our lakes, seas and oceans is twofold—firstly from a sanitary point of view, as purifying agents, and secondly economically as affecting our food supply of fishes. Neither can indeed be easily overrated. As the chief and ever active scavengers of our seas, seizing upon impurities and decomposing matter which might else become a scourge too terrible to contemplate, these minute crustaceans by means of their internal laboratories, convert decay and refuse into their own organizations which in turn become the chief food of fishes. As might naturally be expected, Copepoda are most plentiful near to land, thither probably attracting shoals of fishes, in their turn the valuable food of man. Our direct material indebtedness to Copepoda can thus be easily traced.

In this work as in other matters biological, I have constantly availed myself of the always ready help of my

friend and instructor Professor Herdman, F.R.S. In much of the earlier collecting and sorting out of specimens I enjoyed the co-operation of Mr. W. S. McMillan, F.L.S., and I am indebted to our colleague Mr. A. O. Walker, F.L.S., of Colwyn Bay and to others for material and specimens collected. Lastly my sincere thanks are due to my friend Dr. G. S. Brady, F.R.S., of Sunderland, for frequent help in the examination and confirmation of specimens and whose distinguished work on British Copepoda has formed the chief basis for my classification.

Since completing the manuscript of this Revision the very beautiful and comprehensive work of Dr. Giesbrecht, of Naples, "Pelagische Copepoden," (Fauna und Flora des Golfes Von Neapel, 1892) has appeared, and in a few instances I have adapted the nomenclature in accordance with the results of his important researches. In the following enumeration of species all the measurements given are taken from the rostrum or anterior portion of the cephalothorax to the termination of the caudal segments, and do not include anterior or caudal setæ.

Map of L.M.B.C. District.

COPEPODA.

Family I.—Calanidæ.

Calanus finmarchicus, Gunner. (Pl. XV, fig. 1.)

Length 2.80 mm. A thoroughly pelagic species, common throughout the year but rarely or never taken except in the open sea. When found at considerable depths it is usually of a dark red colour and contains a quantity of oil. It constitutes the chief food of the Greenland whale.

Metridia armata, Boeck. (Pl. XV, fig. 2.)

Length 1.80 mm. Single specimens have been rarely found and only in the open sea at a considerable distance from land. The broad leafy terminations (*a*) of the swimming feet easily distinguish it.

Pseudocalanus elongatus, Baird. (Pl. XV, fig. 3.)

Length 1.30 mm. Very common throughout the district and seldom absent in any townet gathering. The females are often found with three or four large ova.

Pseudocalanus armatus, Boeck. (Pl. XV, fig. 4.)

Length 1.75 mm. A pair of this rare species was taken by surface townet in Port Erin Bay, in 1889, during an illumination of the surface of the sea by electric light from the "Hyæna." Its only other occurrence in the district was in the "Mallard" cruise of 1892 when a single specimen was found among some dredged material taken at a depth of 20 fathoms outside Port Erin. I was at first in doubt whether those specimens were *Ætidius armatus*, Brady, and after careful examination of them with Brady's description of the latter, I am disposed to query whether the two species are not synonymous. The lateral spines of the posterior end of the cephalothorax readily distinguish it from *P. elongatus*.

Paracalanus parvus, Claus. (Pl. XV, fig. 5.)

Length 1.30 mm. One specimen only of this rare form was taken by townet off Puffin Island.

Acartia clausii, Giesbrecht. (Pl. XV, fig. 6.)

Length 1.45 mm. Common in the open sea.

Giesbrecht separates *A. clausii* from *A. longiremis*, the slight points of difference being chiefly in the 5th feet, the spinal termination of the female 5th foot of *A. clausii* (*b*) being much shorter and stronger than that of *A. longiremis*. It is probable that we may have both species but those I have dissected for examination all belong to the former.

Acartia discaudatus, Giesbrecht. (Pl. XV, fig. 6.)

Length 1.20 mm. Taken frequently off the mouth of the Dee and about the Anglesea coast. It may be readily distinguished from *A. clausii* by the caudal segments (*c*) which are about as broad as long.

Temora longicornis, Müller. (Pl. XV, fig. 7.)

Length 1.75 mm. Perhaps the most common British surface species, although rarely or never taken outside British waters. The caudal segments (*b*) form a sufficiently distinguishing feature.

Eurytemora clausii, Hoek. (Pl. XV, fig. 8.)

Length 1.40 mm. Generally met with in brackish water estuaries or pools and in salt marshes. Abundant in pools behind Leasowe embankment.

Eurytemora affinis, Poppe. (Pl. XVI, fig. 1.)

Length 1.75 mm. A large number of this species were taken by townet off the sandbanks at the mouth of the Mersey in 1886. It was not subsequently recorded in the district until 1891, when the filter beds of the Bootle Corporation baths were found to be swarming with it. Mr. Ascroft has since sent me specimens found in tidal pools at Lytham. The males I have found are conspicuous by the number of spermatophores attached to them.

Isias clavipes, Boeck. (Pl. XVI, fig. 2.)

Length 1.60 mm. Frequently taken by townet in the open sea but never abundantly.

In a former paper "Second Report on the Copepoda of Liverpool Bay," Proc. Biol. Soc., L'pool, Vol. II, I pointed out the existence of a pair of curved spines trifid at apex, one on each side of the tubercular genital prolongations on the first abdominal somite of the female. Brady's drawing and description of the fifth foot of the male are not quite correct. He says the inner branch "of the right side is provided with swimming setæ and is two jointed," and he so figures it. This accidental error led M. Canu in "Les Copepodes libres Marins du Boulonnais," (Bulletin Scientifique de la France, Paris, 1888) to suppose that a male specimen he examined differing in the fifth feet from Brady's drawing could not be *I. clavipes* and he accordingly named it *I. bonnieri*. On examining my specimens of *I. clavipes* I found they agreed with Canu's *I. bonnieri*, and on the matter being referred to Dr. Brady he at once saw that Canu's drawing is correct for *I. clavipes*. *I. bonnieri* must therefore be withdrawn.

Centropages hamatus, Lilljeborg. (Pl. XVI, fig. 3.)

Length 1.30 mm. Common in the open and seldom absent from the townets. It is rather surprising that so far as I am aware the allied species *C. typicus* has never been found in the L.M.B.C. district.

Parapontella brevicornis, Lubbock. (Pl. XVI, fig. 4.)

Length 1.30 mm. Occasionally taken in surface townet also rarely in tidal pools. The two lateral abdominal spines (*c*) easily distinguish this species.

Family II.—Pontellidæ.

Labidocera wollastoni, Lubbock.

Length 2.50 mm. During the autumn months we have taken this somewhat rare species plentifully in surface townets off Puffin Island and in the open sea. Males

and females seem equally plentiful. The fifth feet (*b*, *c*, *d*) readily distinguish it.

Labidocera acutum, Dana. (Pl. XVI, fig. 6.)

Length 2.50 mm. One specimen, a male, of this rare exotic species was found in dredged material taken off Puffin Island in 10 fathoms when in company with Dr. Brady.

Anomalocera patersoni, Templeton. (Pl. XVI, fig. 7.)

Length 3.75 mm. This large striking Copepod has been frequently taken in the district, but generally when it has occurred, as on two dredging expeditions round about the Isle of Man, it has been in such profusion for a few days as to almost fill the townets and to be clearly visible on the surface from the steamer's deck. When living it is of a deep green colour interspersed with blue and red but so far I have been unsuccessful in preserving its natural colour. What becomes of these tremendous shoals at other times remains a mystery. Dr. J. Murray considers it unlikely that an animal so coloured could be a deep water species, and we have never taken it at any great depth, nor does it appear to be of wide geographical distribution. Male and females were equally plentiful.

Euchæta marina, Prestandrea. (Pl. XVI, fig. 8.)

Length 3.0 mm. A single specimen of this well known southern species, never I believe before recorded in British seas was found adherent to the branchial sac of an Ascidian dredged by Prof. Herdman in Garwick Bay, Isle of Man. The presence of this animal so essentially a free swimmer, in such a situation is most unaccountable. Its transversely notched rostrum with two sharp teeth readily distinguishes it from any other known species.

Family III.—Misophriidæ.

Misophria pallida, Boeck. (Pl. XXI, fig. 1.)

Length 0.75 mm. An exceedingly rare species, one specimen only having been recorded in the district, dredged in 10 fathoms off Puffin Island in July, 1891. Curiously enough, Boeck and Brady each also found only one specimen. The inner branch of posterior antenna (*b*) in my specimen is itself two branched, the smaller one being one jointed with terminal setæ.

Cervinia bradyi, Norman. (Pl. XXVII, fig. 7.)

Length 1.30 mm. The beautiful stags horn character of the posterior antennæ clearly distinguishes this striking Copepod from any other known species.

The anterior antennæ (*b*) of all of my specimens have a remarkable two jointed branch springing from the base of the third joint, the basal joint being about equal to the third joint of main the branch, and the terminal being very small, both terminated with long plumose setæ. Norman did not observe any fifth feet. They are certainly very small but distinctly present and consist (*a*) of a short basal joint and a longer second joint having one lateral seta and terminated by one long and one short seta. All the specimens taken were (like Norman's) of one sex and were dredged on only one occasion in mud at 39 fathoms about 12 miles out from Port Erin.

Herdmania, n. gen.

First pair of antennæ, (Pl. XXVIII, fig. 11) nine-jointed; second pair (fig. 4) two branched, the primary branch composed of two long joints, the secondary branch of one long joint and three small terminal joints. Mandibles (fig. 5) small, armed with short sharp teeth and palp composed of two one jointed branches.

Maxillæ (fig. 6) with well developed palp, bearing four

appendages, the apical one three jointed. First pair of foot jaws (fig. 7) four jointed, the second foot jaw is not yet determined. The first pair of swimming feet (fig. 8) has its inner branches two jointed, the outer branches three jointed. The second, third and fourth pairs have both branches three jointed. The fifth feet are two jointed in the female, and three jointed in the male.

Herdmania stylifera, n. sp. (Pl. XXVIII, figs. 1—12.)

Length 0.60 mm. Body ovate, rounded anteriorly with a small rounded rostrum. Anterior antennæ of female (fig. 2) nine jointed, the first joint being the largest and produced into a beaky spine at the apex of the inner side. The second and third joints are about equal in length, and both rather smaller than the first. The fourth joint is about one quarter the length of the third; the fifth is about as long as the sixth and seventh together. The eighth is long and narrow, and the ninth is a very small apical prominence. Some of the setæ which thickly clothe the antennæ are plumose. The first joint of the male antennæ (fig. 3) is about the same length as that of the female its beaky spine being recurved downwards, the fourth and following joints forming a vesiculiform swelling, the apical joints being narrow and curved. Posterior antennæ (fig. 4) two branched, the inner branch composed of two joints; the outer branch is considerably shorter and composed of four joints, the basal joint of which is about equal to that of the inner branch, the three terminal segments being very short. Mandibles (fig. 5) have four sharp teeth, and a two branched palp with numerous short setæ. Maxilla (fig. 6) has a large lobe and four branches, the apical of which is composed of three very small joints. First foot jaw (fig. 7) is four jointed and is covered with spines and setæ.

Diligent search of the only two specimens found and

careful dissection of one failed to reveal the presence of posterior foot jaws, so if present any description of these appendages must await the capture of more specimens. Inner branch of first pair of swimming feet (fig. 8) two jointed, the inner side of apical joint being produced into a long digit-shaped spine with rounded end. The outer branch of first pair and both branches of second, third, and fourth feet and of the fifth feet of male are all three jointed, the inner terminations of the first and second joints of the inner branches of the second and fourth feet (fig. 10) forming strong beak like spines. The fifth feet of the female (fig. 11) are two jointed, the second being more than twice the length of the first and bearing three lateral and three apical spinous setæ. The fifth feet of the male (fig. 12) are alike and both three jointed. Abdomen six jointed with sharply pointed lateral terminations to the second, third and fourth segments. Caudal stylets very long and narrow, swollen at the upper end and gradually widening to the base, with outer lateral setæ one on each near the end and having several terminal setæ.

Two specimens only, a male and female of this remarkably elegant but minute species were taken by the mud dredge at 39 fathoms in the Irish Sea about twelve miles out from Port Erin. I feel a peculiar pleasure in connecting the name of the genus with that of my friend Prof. Herdman.

Family IV.—Cyclopidæ.

Oithona spinifrons, Boeck. (Pl. XVII, fig. 1.)

Length 1 mm. Generally present in townet gatherings throughout the year. It is easily recognized by its delicate whip like antennæ clothed with long setæ.

Cyclopina littoralis, Brady. (Pl. XVII, fig. 2.)

Length 0.75 mm. Frequently found amongst sea-weeds between tide marks about Puffin Island. Though seldom

taken in any abundance, I recollect on one occasion finding hundreds in one night's townetting off Puffin Island in May, 1889. The many jointed anterior antennæ serve to distinguish this from the next species.

Cyclopina gracilis, Claus. (Pl. XVII, fig. 3.)

Length 0.45 mm. Less common than the last species, but occurring occasionally in townettings taken near land. Anterior antennæ, eleven jointed.

Cyclops marinus, n. sp. (Pl. XXIX, fig. 1—8.)

Length 1.20 mm. Body ovate (fig. 1) with long abdomen. Anterior antennæ (fig. 2.) 12 jointed, the first joint being the longest, and the eighth almost as long but narrower, the third and sixth joints being very short. Posterior antennæ (fig. 3) four jointed, the joints being of nearly equal length. Mandibles (fig. 4) have six long sharp teeth at apex. Palp reduced to a small tubercle from which spring four spinous setæ. Maxillæ (fig. 5) without palp, having two large teeth at apex and a number of lateral small ones. Anterior foot jaw (fig. 6) four jointed, with numerous spinous setæ, some of them plumose. Posterior foot jaw (fig. 7) three jointed, the upper one dividing into three branches terminated with spinous setæ.

First four pair of swimming feet (fig. 8) all three jointed, the inner joint of all except the fourth pair having a curved spine at the apex. Fifth feet (fig. 9) two jointed, the second joint being more than double the size of the first and having seven strong setæ. Abdomen four jointed, the first joint being nearly as long as the second and third together. Caudal segment about three times as long as broad, each bearing five terminal setæ and one short lateral seta.

Two specimens only, both females were dredged in 20 fathoms about 20 miles out from Southport pier, during the "Mavis" expedition.

Through scarceness of specimens and absence of males I regret the necessarily imperfect description of this very important addition to our fauna of a marine species of Cyclops, assuming as seems probable that *Cyclops ewarti*, Brady, found by Mr. T. Scott, F.L.S., about five miles above Queen's Ferry, Firth of Forth, 1887, may have found its way thither from a fresh water source.

Thorellia brunnea, Boeck. (Pl. XVII, fig. 4.)

Length 1.30 mm. Solitary specimens are occasionally taken in the open sea and in dredged material.

Hersilioides puffini, Thompson. (Pl. XVII, fig. 5.)

Length 0.80 mm. A few specimens were taken by townet off Puffin Island a few years ago when weekly gatherings of material were sent to me from there for examination, but it has not occurred since in the district.

Giardella callianassæ, Canu. (Pl. XVII, fig. 6.)

Length 0.75 mm. A single specimen was taken by townet in Liverpool Bay during the "Despatch" expedition, 1886. This species was described by M. Canu in "Bulletin Scientifique" series III, 1888, p. 410.

Family NOTODELPHYIDÆ.

Notodelphys allmani, Thorell. (Pl. XVII, fig. 7.)

Length 4.0 mm. A few specimens were found by Prof. Herdman in the branchial sacs of the Ascidian *Ciona intestinalis* dredged off the south end of the Isle of Man.

Doropygus pulex, Thorell. (Pl. XVII, fig. 8.)

Length 1.30 mm. Found by Prof. Herdman in company with the preceding species, and also in the branchial sac of *Ascidiella scabra*, dredged in Groudle Bay, Isle of Man; also in the branchial sac of *Ascidia plebeia*, dredged from the "Hyæna," off the Calf of Man, in twenty fathoms. The male (*b*) is smaller than the female (*a*).

Doropygus poricauda, Brady. (Pl. XVIII, fig. 1.)

Length 2.50 mm. One specimen of this species was amongst several of the last preceding taken from the branchial sac of *Ascidia plebeia*.

Doropygus gibber, Thorell. (Pl. XVIII, fig. 2.)

Length 3.20 mm. Found in the branchial sac of *Ascidia plebeia* dredged from the "Hyæna" in 1890.

Botachus cylindratus, Thorell. (Pl. XVIII, fig. 3.)

Length 1.75 mm. Found by Professor Herdman in the branchial sacs of *Ascidia mentula* and *Ascidia plebeia*, from the Isle of Man.

Thorell and so far as I know all subsequent observers have failed to find the male of this species. In each of the several ascidians in which the females were found were a few minute specimens which generally correspond to the males of other species and are evidently the male of *Botachus cylindratus*. (Fig. 3. *a*.) Prof Herdman tells me that they were in appearance like minute commas attached to the inner folds of the branchial sac of the Ascidian, and from their minute size and very tenacious hold might easily be overlooked.

Ascidicola rosea, Thorell. (Pl. XVIII, fig. 4.)

Length 3.75 mm. Several specimens of this species have been found in the branchial sacs of Ascidians dredged off the Isle of Man.

Notopterophorus papilio, Hesse. (Pl. XVIII, figs. 5, 6.)

A few specimens of each, male and female of this most remarkable and beautiful Copepod were found in Ascidians dredged in Garwick Bay, Isle of Man by Prof. Herdman. The female is described by Brady (Copepoda of British Islands, Ray Society, Vol. I, p. 142) from Hesse's first memoir in which no mention is made of the male. It was subsequently however found by him and briefly described in a later paper but not figured. It is about 2 mm. in length, the female measuring about double that size.

The Cephalothorax has five segments the head segment being distinct from the rest. The second and third segments have each a pair of dorsal papillæ projecting laterally and upwards, and the fourth has one larger dorsal papilla. The abdomen is about equal in length to the rest of the body and is composed of three segments each being about twice as long as broad, and terminated like the female with short caudal segments armed with hook spines. The two pair of antennæ are similar to those of the female as are the other appendages and first four pair of swimming feet. The fifth pair are however wanting in the female, while the male possesses a pair of two jointed fifth feet each terminated by a single seta.

As was the case with the specimens examined by Brady the wing-like expansions of the females we found were somewhat lacerated from immersion in alcohol but their general form and long pointed apices are very characteristic. The terminal posterior wing is decidedly larger than that in Brady's drawing and though too lacerated to be certain of its form, it affords indication of the three pointed terminations figured from Hesse. The cephalothorax in our female specimens is much more robust than in Brady's drawing the last body segment being the widest and filled with ova. The first and second abdominal segments are funnel shaped, the narrow extremity of which is the same width as the two terminal segments which are of similar size to those of the male.

It is difficult to imagine any use to the animal of the extraordinary appendages in the female so much resembling in general appearance the wings of a butterfly.

Family HARPACTICIDÆ.

Longipedia coronata, Claus. (Pl. XVIII, fig. 7.)

Length 1.25 mm. One of the commonest of British

species. Common both as a free swimmer and in material dredged from a sandy bottom. It is easily recognised by its beautiful plumed anterior antennæ and by the length of the inner branch of the second swimming feet.

Ectinosoma spinipes, Brady. (Pl. XVIII, fig. 8.)

Length 1.25 mm. Frequent in dredged material from a muddy bottom about low water mark.

Ectinosoma curticorne, Boeck. Pl. XVIII, fig. 8. *e.*)

Length 1.25 mm. This species is so nearly allied to the foregoing that I feel very doubtful as to its separate identity. The only important difference appears to be in the fifth feet and even here the gradation from one to the other is very slight.

Ectinosoma erythrops, Brady. (Pl. XVIII, fig. 8. *c. d.*)

Length 0.75 mm. Occasionally dredged in 10 fathoms off Puffin Island, and in 4 fathoms in Port Erin Bay. Its two brilliant red eye spots and the small size of the fifth feet are its distinguishing features.

Ectinosoma melaniceps, Brady. (Pl. XXI, fig. 2. *a.*)

Length 0.75 mm. Very similar in character to the three former species. Brady says "it is much smaller and more delicate in structure than *E. spinipes*, and is moreover always distinguished by a cloudy blackish patch on the head." We have taken it in the dredge at Port St. Mary and off the Calf of Man.

Ectinosoma atlanticum, Brady & Rob. (Pl. XIX, fig. 1.)

Length 0.50 mm. An easily distinguished species of slender build, long and narrow. Taken by townet in the open sea occasionally, and on one occasion by electric light in Port Erin Bay.

Tachidius brevicornis, Müller. (Pl. XXI, fig. 2. *b. c.*)

Length 0.80 mm. A brackish water species. We have taken it in quantity from material sent by Mr. Dwerryhouse from a brackish tributary of the Mersey at Hale,

also at the mouth of the Alt. The broad square fifth feet of the female (*b*) serve to distinguish it.

Tachidius littoralis, Poppe. (Pl. XIX, fig. 2.)

Length 0.60 mm. Very similar to *T. brevicornis* but differing chiefly in the anterior antennæ and the fifth feet. Found in fucus about low water mark at Penmon Point and Puffin Island.

Euterpe acutifrons,* Dana. (Pl. XIX, fig. 3.)

Length 0.50 mm. Frequently taken by townet in the open sea and near to Puffin Island during the autumn months especially. Males and females equally common. I have generally been able to detect this species in material from its crescent shaped appearance.

Robertsonia tenuis, Brady & Robertson. (Pl. XIX, fig. 4.)

Length 0.60 mm. A rare species. Taken by dredge on two occasions in 10 fathoms off Puffin Island.

Amymone sphærica, Claus. (Pl. XIX, fig. 5.)

Length 0.38 mm. Occasionally dredged off Puffin Island and found in dredged material sent by Mr. A. O. Walker from Colwyn Bay, and recently in Port Erin Bay.

Although some of our specimens differ from Claus's drawings in being less spinous I can see no good reason for supposing them not to be the same species.

Amymone longimana, Claus. (Pl. XIX, fig. 5. *b*.)

Length 0.50 mm. The only specimen we have taken was dredged in 5 fathoms off Port Erin. Distinguishable from the previous species by the posterior foot jaw (*b*).

Stenhelia hispida, Brady. (Pl. XIX, fig. 6.)

Length 0.35 mm. Found in rock pools at Hilbre and Puffin Islands; also in mud taken at Garth Ferry at low water, and in Port Erin Bay. The chitinous spear like inner branch of the male second foot is a distinguishing feature.

* *E. gracilis* in plate.

Stenhelia ima, Brady. (Pl. XXI, fig. 2. *d. e. f.*)

Length 1.25 mm. Dredged in Soderick Bay, Rhos Colin Bay, and Port Erin Bay, but nowhere common. Recognizable by the swollen bases of the caudal setæ (*f*).

Stenhelia denticulata, n. sp. (Pl. XXX, fig. 1—11.)

Length 1 mm. Body ovate with long rostrum. Anterior antennæ (fig. 2) 8 jointed, the first and third joints being about twice as long as broad; the second and fourth about three times as long as broad, the latter having a long filament at apex; the four terminal joints are together, about the length of the fourth. The first joint has a small tooth and the second joint has a strong tooth on the under side. Posterior antennæ (fig. 3) three jointed with inner branch also three jointed. Mandible (fig. 4) has toothed apex and two one jointed lateral protuberances.

Anterior foot jaw (fig. 6) two jointed, the apical joint terminated by several spinous setæ and having two lateral branches. Second foot jaw (fig. 7) with falciform claw. Four first pair of swimming feet (figs. 8 and 9) have inner and outer branches all three jointed. Fifth feet composed of triangular basal joint with lengthened tapering joint springing from it, both bearing spinous setæ. Abdomen five jointed, about the same length as the rest of the body. Caudal segments about as long as broad; each having two long central apical setæ and one small one on either side. Two specimens only, both females were dredged from the muddy bottom inside Port Erin breakwater.

Stenhelia hirsuta, n. sp. (Pl. XXXI, fig. 1—13.)

Length 1 mm. Rostrum long and pointed. Anterior antennæ (figs. 2, 3) eight jointed, the first, second and fourth being much larger than the others; thickly covered with long setæ. Inner branch of posterior antennæ (fig. 4) three jointed, the middle one very small. Claw of second foot jaw (fig. 8) is swollen at base, the inner margin of hand bearing two spinous setæ and several short setæ.

First, second, third, and fourth swimming feet (figs. 9—11) all three jointed in both branches with the exception of the inner branch of the second feet in the male (fig. 10) in which a pair of stout claws takes the place of the 3rd joint. The inner branch of the first pair (fig. 9) is nearly twice the length of the outer, its basal joint being about equal in length to the two following joints. Basal joint of fifth feet (fig. 12) broad and long in the female with fine terminal spinous setæ. Second joint ovate with several lateral spines and long terminal spine. The fifth feet of the male (fig. 13) are smaller and more angular than those of the female and have fewer spines. The caudal stylets are slightly tapering towards the apex and are about three times as long as broad. A few specimens, male and female were dredged in mud at 39 fathoms in the Irish Sea about 12 miles west from Port Erin. The hirsute character of the antennæ, the inner branch of the second foot in the male together with the caudal stylets serve to distinguish the species from others of the genus.

Ameira longipes, Boeck. (Pl. XIX, fig. 7.)

Length 0.45 mm. Dredged in 20 fathoms off the Calf of Man, also off Puffin Island, and the Little Orme. Brady speaks of the perplexing resemblance between this species and *Stenhelia ima*. The length of the caudal segments however readily distinguishes them, being about five times as long as broad in the former and very short in the latter species.

Ameira attenuata, n. sp. (Pl. XXXII, figs. 1—11.)

Length 0.40 mm. Rostrum short, obtuse. Anterior antennæ (figs. 3 and 4) eight jointed in the female, seven jointed in the male, the short penultimate joint being absent in the latter. The second joint is much longer and wider than any of the others. In the male (fig. 4) a hinge

occurs between the 5th and 6th joints. A long filament springs from the 4th joint. Posterior antennæ (fig. 5) two jointed, the inner branch being composed of one joint with three terminal setæ.

Hand and claw of the second foot jaw slender. First joint of the inner branch of first pair of swimming feet (fig. 7) about the same length as the entire outer branch, the middle joint has two small setæ on the inner side; the outer side of the outer joint is ciliated. Both branches of the second, third and fourth feet (fig. 8) are three jointed. The basal joint of the fifth pair of female (fig. 9) is triangular bearing three terminal setæ: the second joint is long, slightly oval, ciliated at each side and bearing four setæ. The fifth feet of the male (fig. 10) are very similar to those of the female but are rather smaller, and not ciliated and have fewer setæ. The abdomen of the female is five jointed, in the male four jointed. Caudal segments about four times as long as broad and slightly tapering, terminated by two long and several short setæ.

Several specimens of this species nearly all females were lately found in mud dredged from seven fathoms inside Port Erin breakwater. Their extreme minuteness and delicacy render dissection difficult and the mouth organs I have not been able to make out clearly.

Jonesiella fusiformis, Brady & Rob. (Pl. XIX, fig. 8.)

Length 1.25 mm. Dredged off the Calf of Man in 20 fathoms and off Puffin Island.

Jonesiella hyænæ, Thompson, (Pl. XX, fig. 1.)

Length 0.65 mm. First dredged from steamer "Hyæna" in Port Erin Bay, and since found there in considerable number on a muddy bottom. It is described in Appendix to 3rd Report on the Copepoda of Liverpool Bay. Proc. L'pool Biol. Soc., 1888-9, Vol. III, p. 192.

Bradya typica, Boeck. (Pl. XIX, fig. 8. *b. c.*)

Length 0.80 mm. A few specimens all females were recently dredged with mud in Port Erin Bay.

Delavalia palustris, Brady. (Pl. XX, fig. 2.)

Length 0.80 mm. Several of this mud loving species have been found in mud taken about Puffin Island, Port Erin, Garth Ferry, and Hale. Among them is one male which so far as I am aware has not been hitherto known.

Delavalia reflexa, Brady and Robertson. (Pl. XX, fig. 3.)

Length 0.70 mm. One specimen a female was dredged in 20 fathoms in Redwharfe Bay, Anglesea, and one male was found in mud from Garth Ferry taken at low water.

Mesochra lilljeborgii, Boeck. (Pl. XX. fig. 4.)

Taken by townet off Puffin Island, also found in mud taken in a brackish tributary of the Mersey at Hale.

Paramesochra dubia, Scott. (Pl. XXVII, fig. 8. *a.*)

Length 0.65 mm. Quantities of this species recently described and figured by Mr. Thomas Scott, F.L.S. (Tenth Annual Report of the Fishery Board for Scotland) I found in mud dredged at 7 fathoms in Port Erin Bay, males and females being equally plentiful. Since then I find it in mud collected by Mr. Corbin from the Duddon cockle beds at the mouth of the River Duddon near Barrow.

Tetragoniceps bradyi, Scott. (Pl. XXVII, fig. 8. *b.—f.*)

Length 1 mm. Found only at same times and habitat as the last named species, (*Paramesochra dubia*) Scott found no males; they were however plentiful in the Port Erin gathering. The conspicuous 5th feet (*c*) at once render the female of this species recognisable.

Diosaccus tenuicornis, Claus. (Pl. XX, fig. 5.)

Length 1.30 mm. Found in rock pools at Hilbre and Puffin Islands, and dredged in Port Erin Bay. It is distinguishable by its long anterior antennæ (*a*).

Laophonte serrata, Claus. (Pl. XX, fig. 6.)

Length 1.0 mm. Taken in townet by electric light at Port Erin, also between the Isle of Man and Liverpool and off Puffin Island, but rare.

Laophonte spinosa, n. sp. (Pl. XXXIII, figs. 1—13.)

Length 1 mm. Body elongated, the first segment being about equal in length to the five following segments. Rostrum short and blunt. Anterior antennæ (figs. 2, 3) four jointed, and with marked differences bearing a general similarity in both sexes to those of *Laophonte serrata* and even more serrated than in the latter species. The second joint has a large, strong spine in both sexes. The third joint in the female is longer than the others and is less setose than that of *L. serrata*. Fourth joint of male very similar to that of *L. serrata*, the others being dissimilar. Posterior antennæ (fig. 4) very similar to *L. serrata*. Mandible (fig. 5) bluntly spinous with small setiferous palp. Posterior foot jaw (fig. 7) is slender with very long slender claw.

The peduncle of first pair of feet (fig. 8) is composed of two long slender joints, the outer branch two jointed and very slender springing from the middle of second peduncle joint and about half the length of the first joint of inner branch which is armed with a strong falciform terminal claw. The two jointed outer branch of second, third and fourth feet (figs. 9, 10) in the female is nearly as long as the three jointed inner branch.

The fifth pair of feet in the female (fig. 12) have large triangular basal joints with three curved lines of fine markings on the surface; they have five plumose setæ, The second joint is ovate and is attached laterally to first joint and also has five plumose spinous setæ. The fifth feet of the male (fig. 11) are very small and two jointed. The caudal segments (fig. 13) are about four times as long

as broad and have each a strong curved claw extending dorsally situated rather above the centre, two strong spinous setæ adorning the opposite side. The caudal segment is terminated by a strong central spine, and on the inner side has a stout bluntly rounded spine about half the length of the caudal segment, and a short fine seta on the outer side.

Two specimens, male and female of this strongly marked Copepod were lately dredged at a depth of seven fathoms on the muddy ground inside Port Erin breakwater. In the general character of the antennæ this species somewhat resembles *L. serrata* for which it might at first sight be mistaken, but the swimming feet are different, and the caudal segments and their remarkable appendages clearly distinguish it from any known species.

Laophonte thoracica, Boeck. (Pl. XXI, fig. 5. *e.—g.*)

Length 0.60 mm. Our only specimen was taken by townet amongst the Algæ round Puffin Island.

Laophonte horrida, Norman. (Pl. XX, fig. 7.)

Length 1.25 mm. This ferocious looking animal is at once recognisable by its array of dorsal projecting spines. A few specimens male and female were recently dredged at four fathoms in Port Erin Bay and one specimen was dredged at 39 fathoms, 12 miles from Port Erin. They were imbedded in mud which was so tenaciously held by the spines that it was most difficult to clean them. It appears to be an exceedingly rare species.

Laophonte similis, Claus. (Pl. XXI, fig. 5. *a.—d.*)

Length 1 mm. Found in tidal pools about the submarine forest at Leasowe, also in dredged material from Colwyn Bay.

Laophonte curticauda, Boeck. (Pl. XXI, fig. 3.)

Length 1 mm. Found in tidal pools at Hilbre Island, Leasowe, and Puffin Island.

Laophonte lamellifera, Claus. (Pl. XX, fig. 8.)

Length 0.85 mm. Frequently taken by townet amongst the Algæ about Puffin Island.

Laophonte hispida, Brady & Robertson. (Pl. XXI, fig. 4.)

Length 1.80 mm. One specimen only was taken by surface townet near Puffin Island.

Normanella dubia, Brady and Robertson. (Pl. XXI, fig. 6.)

Length 0.40 mm. A few specimens of this very minute species were dredged in mud from four fathoms in Port Erin Bay.

Cletodes limicola, Brady. (Pl. XXI, fig. 7.)

Length 0.80 mm. Found in mud taken at low water at Penmont Point, Anglesea, and at Garth Ferry.

Cletodes longicaudata, Brady & Rob. (Pl. XXI, fig. 8. *f.*)

Length 0.50 mm. Found sparingly in mud from Llanfairfechan shore at low water. The long, thin caudal segments (*f*) readily distinguish it.

Cletodes linearis, Claus. (Pl. XXI, fig. 8. *a.—c.*)

Length 1 mm. Found in mud from Hale shore taken at low water.

Cletodes monensis, n. sp. (Pl. XXXIV, figs. 1—11.)

Length about 1.20 mm. First joint of cephalothorax about equal to the two following and armed with a strong slightly hooked spine on the dorsal side. A double spine terminates the posterior dorsal end of abdomen. A minute row of spines clothes the edges of all the cephalothoracic and abdominal segments, with the exception of the first.

Anterior antennæ (fig. 2) seven jointed, the first being the longest, and the second about equal to any two of the following. Posterior antennæ (fig. 3) three jointed a single stout seta taking the place of an inner branch. First pair of swimming feet (fig. 8) very small, the second, third and fourth gradually increasing in length, the fourth (fig.

9) being more than double the length of the first. The inner branch of all four is very short, two jointed, and terminated by a long seta; the outer branch of each is much longer than the inner and is three jointed, it being in the fourth feet at least six times the length of the inner branch. The fifth feet (fig. 10) are each composed of three inner spines, the central one plumose, then a long single segment with spinous apex, and the foot terminated by a short segment bearing a long seta. Caudal stylets (fig. 11) long and narrow with one outer seta near apex and a central inner seta, and long terminal spines. Several specimens all females of this striking species were taken by the mud dredge at a depth of 39 fathoms about 12 miles out from Port Erin. It is easily recognised by the anterior and posterior dorsal spines, its stout build and long diverging caudal stylets.

Enhydrosoma curvatum, Brady & Rob. Pl. XXII, fig. 1.)

Length 0.60 mm. Found in mud from Llanfairfechan and Garth shores at low water. Its minute size and its adherence to its muddy surroundings render it difficult of detection or examination.

Platychelipus littoralis, Brady. (Pl. XXII, fig. 2.)

Length 1.20 mm. This striking species occurs in abundance in mud taken at low water at Puffin Island, Llanfairfechan, Garth Ferry and Hale, males and females being about equally plentiful.

Dactylopus tisboides, Claus. (Pl. XXII, fig. 3.)

Length 1.90 mm. Frequently dredged off Puffin Island and Port Erin, also found in tidal pools. It is easily distinguishable by the first pair of feet (*b*) and by the markings on the fifth feet (*c*).

Dactylopus stromii, Baird. (Pl. XXII, fig. 4. *a. b.*)

Length 1. mm. Frequently found in tidal pools and attached to Algæ. It bears considerable resemblance to

D. tisboides the anterior antennæ of the latter however is nine jointed, that of *D. stromii* being eight jointed.

Dactylopus tenuiremis, Brady& Rob. Pl. XXII, fig. 4. *c.d.*)

Length 0.80 mm. One specimen only taken by surface townet near Port Erin. Its caudal segments (*d*) form a distinguishing feature.

Dactylopus flavus, Claus. (Pl. XXIII, fig. 5. *a.—d.*)

Length 0.80 mm. This is evidently a rare species. We have occasionally taken it, by dredge off or near the Calf of Man in 20 fathoms. It is of a dark yellow colour and easily recognizable by its short compact somewhat boat-shaped appearance.

Dactylopus brevicornis, Claus. (Pl. XXII, fig. 4. *e. f. g.*)

Length 0.60 mm. A few specimens were found in tidal pools at Douglas, Isle of Man. The short, densely setose anterior antennæ at once distinguish it from others of the genus.

Dactylopus minutus, Claus. (Pl. XXII, fig. 5. *e. f.*)

Length 1. mm. A single specimen was dredged in 20 fathoms near the Calf of Man. It is evidently one of the rarest species of the genus.

Thalestris helgolandica, Claus. (Pl. XXII, fig. 7.)

Length 0.80 mm. A few specimens have been dredged off the Little Orme and near Puffin Island, also in Port Erin Bay. The presence of a middle joint in the inner branch of the posterior antennæ and the shape of the fifth feet sufficiently distinguish this species.

Thalestris rufocincta, Norman. (Pl. XXII, fig. 6.)

Length 1.25 mm. Common both free swimming and in dredged material throughout the district. It is of a yellowish colour, the edges of the body segments being usually lined with crimson. This together with the plumose character of the spines on the swimming feet (*a*) easily distinguish it.

Thalestris harpactoides, Claus. (Pl. XXII, fig. 8.)

Length 1.25 mm. Frequent in rock pools about Puffin Island and Douglas. This rarer species somewhat resembles *T. rufocincta* in colour. It is however more slender and may be recognised by the aculeate character of its caudal setæ.

Thalestris clausii, Norman. (Pl. XXII, fig. 6. *b. c.*)

Length 1 mm. Found in tidal pools at Fleshwick Bay, Isle of Man, and at Puffin Island. The first pair of swimming feet serve to distinguish it.

Thalestris rufo-violescens, Claus. (Pl. XXIII, fig. 1.)

Length 1. mm. A rare species in the district. A few specimens were found in mud dredged from 4 fathoms in Port Erin Bay. The chitinous character of the edges of most of its segments is a very distinguishing feature. This is specially noticable on the joints of the anterior antennæ (*a*) and in the fifth feet (*d*).

Thalestris serrulata, Brady. (Pl. XXIII, fig. 2. *a.*)

Length 2. mm. One specimen was taken by surface townet off Puffin Island. The widely separated serrated markings on the outer edge of the caudal segments (*a*) seem a strong distinguishing feature.

Thalestris hibernica,Brady&Rob. (Pl.XXIII,fig.2.*b.—f.*)

Length 0.80 mm. A few specimens were found in rock pools at Hilbre and Puffin Islands. It may be recognized by the fifth feet (*e*).

Thalestris longimana, Claus. (Pl. XXIII, fig. 3. *a. b.*)

Length 1.30 mm. Common in rock pools at Hilbre and Puffin Islands. The powerful posterior foot jaw renders it easily recognizable.

Thalestris peltata, Boeck. (Pl. XXXIII, fig. 3. *c. d.*)

Length 0.80 mm. A few specimens were found in material dredged off Little Orme and more recently at 20 fathoms off Port Erin. Its ovate form, rostrum and eye

spot distinguish this species from the others of the genus.

Westwoodia nobilis, Baird. (Pl. XXXIII, fig. 4.)

Length 1. mm. Occasionally found in rock pools at Hilbre and Puffin Islands. The one jointed inner branch of the feet of the first pair at once distinguishes this species.

Harpacticus chelifer, Müller. (Pl. XXXIII, fig. 5.)

Length 1.25 mm. Common throughout the district as a free swimmer and in dredged material. The chelifate posterior foot jaw (*c*) clearly distinguishes this species.

Harpacticus fulvus, Fischer. (Pl. XXXIII, fig. 6. *a.b.c.*)

Length 1.25 mm. Abundant in rock pools at Puffin Island, generally of a bright red colour and very conspicuous on the green alga *Enteromorpha.*

Prof. Herdman's experiments as to the capacity of this crustacean to adapt itself to various degrees of salt and fresh water are given in Report III of the Marine Biological Station on Puffin Island, 1889, p. 36.

Harpacticus flexus, Brady & Rob. (Pl.XXXII,fig. 6.*d.e.f.*)

Length 1.25 mm. Very similar in general appearance and characters to *H. chelifer*, but smaller and recognizable by the second foot jaw which is slender and without the excavated toothed hand so characteristic of that species.

Zaus spinatus, Goodsir. (Pl. XXIII, fig. 7.)

Length 0.65 mm. A pretty minute species frequently found in tidal pools at Hilbre and Puffin Islands, &c.; also dredged in Port Erin Bay.

Zaus goodsiri, Brady. (Pl. XXXIII, fig. 8.)

Length 1.30 mm. Dredged off the Calf of Man in 20 fathoms and off the Little Orme, and in Colwyn Bay. In some of the specimens from the first locality the three central body segments are of a brilliant crimson colour.

Alteutha depressa, Baird. (Pl. XXIV, fig. 1. *c.*)

Length 1.30 mm. Common throughout the district, chiefly a littoral species, also frequently found in the night

surface townets as a free swimmer. On some occasions when we have left a townet tied to a buoy all night, numbers of this species have been captured.

Alteutha interrupta, Goodsir. (Pl. XXIV, fig. 1. *a. b.*)

Length 1.30 mm. Frequently found in similar situations to the last species. The shape of the terminal joint of the fifth feet (*b*) and the number of the spines thereon distinguish this from the preceding species.

Alteutha crenulata, Brady. (Pl. XXIV, fig· 2.)

Length 1 mm. A gaily coloured uncommon species. Our examples have been taken in Redwharfe Bay, Anglesea, and about Puffin Island, chiefly amongst the littoral Algæ.

Porcellidium tenuicauda, Claus. (Pl. XXIV, fig. 3.)

Length 1 mm. Our only specimen was dredged from the "Mallard" (1892) outside Port Erin Bay in 20 fathoms.

Porcellidium viride, Philippi. (Pl. XXIV, fig. 3. *a.*)

Length 0.80 mm. One specimen only was dredged in Port Erin Bay amongst mud, at 4 fathoms. The caudal segments of this species (*a*) distinguish it from the preceding species.

Idya furcata, Baird. (Pl. XXIV, fig. 4.)

Length 1.25 mm. Common throughout the district amongst Algæ and in rock pools; also common as a free swimmer near the land. The tufts of plumose setæ at the apices of the spines of the first pair of feet at a glance distinguish this species.

Scutellidium tisboides, Claus. (Pl. XXIV, fig. 5, *a* to *c.*)

Length 0.65 mm. One specimen only recorded in the district, taken by townet in Douglas Bay.

Scutellidium fasciatum, Boeck. (Pl. XXIV, fig. 5. *d* to *f.*)

Length 1 mm. Not uncommon in tidal rock pools at Hilbre Island; also dredged in Port Erin Bay, where it was also taken by townet during electric light illumination. One specimen, found in a tidal pool at Hilbre Island, has

minute nodules in the middle of many of the setæ of the swimming feet.

Cylindropsyllus lævis, Brady. (Pl. XXV, fig. 6.)

Length 1.20 mm. One specimen only of this easily recognizable species was recently taken by the dredge on the muddy bottom inside of Port Erin breakwater, the only specimen recorded in the L.M.B.C. district. Under high magnification the entire surface is seen to be finely dotted. A spermatophore is in this specimen attached to the first abdominal segment.

Family MONSTRILLIDÆ.

Monstrilla rigida, Thompson. (Pl. XXIV, fig. 6. *a.*)

Length 1.75 mm. One specimen taken by townet off Puffin Island. This species has two abdominal segments, and three setæ on each furcal segment.

Monstrilla danæ, Claparède. (Pl. XXIV, fig. 6. *b.*)

Length 1.30 mm. One specimen was taken by townet about two miles from Puffin Island, and lately several have turned up near Port Erin Bay, one haul of a townet capturing three. This species has three abdominal segments, and four setæ on each furcal segment.

Monstrilla anglica, Lubbock. (Pl. XXIV, fig. 7.)

Length 1.75 mm. Two specimens have been taken by townet off Puffin Island, three years apart. This species has four abdominal segments and five setæ on each furcal segment.

Monstrilla longicornis, Thompson. (Pl. XXIV, fig. 8.)

Length 1.50 mm. One specimen was taken by townet off Puffin Island in 1889. This species has four abdominal segments and four setæ on each furcal segment. It may be easily recognised by its long straight antennæ which are nearly as long as the entire body. It appears to be identical with a single specimen recently described by

Giesbrecht (Pelagischen Copepoden des Golfes von Neapel, 1892) as *M. longiremis* but as his only specimen was a female, and mine a male, there must still remain some doubt as to their identity.

Family SAPPHIRINIDÆ.

Lichomolgus fucicolus, Brady. (Pl, XXV, fig. 1.)

Length 1 mm. Frequently found amongst Algæ round Puffin Island, also in dredged material from Colwyn Bay, and Port Erin Bay.

Lichomolgus liber, Brady & Rob. (Pl. XXV, fig. 2. *a. b.*)

Length 1.30 mm. Dredged off Calf of Man in 20 fathoms, and in Port Erin Bay in 4 fathoms.

Lichomolgus thorellii, Brady & Rob. Pl. XXV, fig. 2. *c.*)

Length 1.80 mm. One specimen found in mud dredged in Port Erin Bay, in 4 fathoms.

Lichomolgus furcillatus, Thorell. (Pl. XXV, fig. 3.)

Length 1 mm. A few specimens occurred in mud dredged in Port Erin Bay, in 4 fathoms.

Lichomolgus albens, Thorell. (Pl. XXV, fig. 3. *c.*)

Length 1·20 mm. In algæ on rocks at Puffin Island.

Lichomolgus agilis, Scott. (Pl. XXV, figs. 4* and 8. *d.*)

Length 1.25 mm. This species was very recently described by Scott (Ann. and Mag. of Nat. Hist., Sept., 1892) who found it plentiful in the shell of the cockle (*Cardium edule*) in specimens from Morecambe, Lancashire, and from the Firth of Forth. Upon examining fresh cockles of our district I found several specimens of this active little Copepod in every bivalve opened. They may be readily found by carefully taking up the water contained in the shell by means of a camel hair brush and washing it into water contained in a watch glass under the microscope when they will probably be seen actively

* Labelled *L. albens* by mistake.

darting about. In general appearance it much resembles *L. albens*, Thorell, but is easily distinguishable from this and other species of the genus by the inner branch of the fourth pair of swimming feet which is three jointed (fig. 4. *d.*) while in the other species it is two jointed. The anterior antennæ are also diagnostic.

Lichomolgus maximus, n. sp. (Pl. XXXV.)

Length of female 2.60 mm. Length of male 1.65 mm. Cephalothorax ovate, composed of five segments, the first being more than half the entire length. Rostrum short and blunt. Anterior antennæ (fig. 3) about two-thirds the length of the first segment, seven jointed and alike in male and female. The proportionate lengths of the joints are about as follows:

1	2	3	4	5	6	7
6	16	4	12	9	6	4

and all are well supplied with setæ. Posterior antennæ (fig. 4) stout, four jointed, the first and second joints being of about equal length, the third and fourth rather smaller. The apical joint is terminated by a pair of powerful curved claws and four hooked spines.

Mandible (fig. 5) is curved with a fringe of short spines at the upper apical portion, short cilia fringing the similar portion of the under side; the palp has two fine terminal spines. Anterior foot jaw (fig. 6) is long and sickle shaped with tooth shaped spines on the upper side gradually increasing in size from the apex. The posterior foot jaws differ in the two sexes. That of the male (fig. 7) is three jointed, the middle joint of which is lined with short setæ upon the inner edge, the third joint being very small. From the latter springs a long curved falciform terminal claw with a slight protuberance in the middle on the under side. There is also a small curved spine springing from the same base. The female foot jaw (fig. 8) is three

jointed and bears at the apex a small papilla or protuberance without any spine or setæ.

The first four pairs of swimming feet have both branches three jointed. In the outer branch of the first pair (fig. 9) the second joint has one and the third joint three spines with foliaceous expansions and aculeate edges. The spines of the other swimming feet are mostly foliaceous but not aculeate. The fourth pair (fig. 10) has two foliaceous spines on the third segment of the outer branch, being terminated by a long dagger-like spine and having five very long lateral plumose setæ. The third inner joint of the fourth pair has one long and one short terminal spine but no lateral setæ. The fifth feet (fig. 11) which are alike in both sexes are composed of one joint with one long and one short terminal spine.

The abdomen of the male is five jointed, that of the female being four jointed. In the male the first joint has two leafy pointed folds each terminating posteriorly with three short spines. The four terminal joints are nearly equal in length and gradually narrower to the extremity. The first joint in the female abdomen is broad and rounded posteriorly and devoid of spines; the other joints are much the same as those of the male. The caudal segments are about eight times as long as broad and equal in length to the two last abdominal segments. Each has four terminal setæ and one lateral seta at one sixth of the distance from the extremity.

About half a dozen specimens of each sex were obtained by carefully washing the branchial folds and other parts of specimens of *Pecten maximus* dredged at 20 fathoms near Port Erin Bay. I was led to look for this unknown Copepod through the similar habitat of *Lichomolgus agilis*, Scott, as parasitic on *Cardium edule.* Its size, nearly twice that of any hitherto described species of

Lichomolgus renders the name appropriate. It agrees with *L. agilis* in having the inner branch of the fourth pair of swimming feet three jointed but differs from it in most particulars, especially in the posterior antennæ and foot jaws. It seems probable that many more parasitic species may be found in similar habitats.

Sabelliphilus sarsii, Claparède. (Pl. XXV, fig. 5.)

Length 2 mm. This species was first found in the L.M.B.C. District and sent to me by Mr. H. Chadwick of Manchester upon the tentacles of a species of *Sabella* found on the Beaumaris shore, to which they were tenaciously adherent. Finding no record of it I described the species as *Lichomolgus sabellæ*, but since then find it is synonymous with *Sabelliphilus sarsii*, Claparède, to which I now assign it. I have since found it on Puffin Island adherent to the tentacles of *Sabella*.

Family Artotrogidæ.

Cyclopicera nigripes, Brady & Robertson. (Pl. XXV, fig. 7.)

Length 1.25 mm. Occasionally dredged off Puffin Island.

Cyclopicera lata, Brady. (Pl. XXV, fig. 8.)

Length 1.75. Isolated specimens have been dredged off Puffin Island, and in the Isle of Man, off Port Soderick and in Port Erin Bay.

Cyclopicera gracilicauda, Brady. (Pl. XXVI, fig. 1.)

Length 0.75 mm. Taken by townet off Puffin Island; and by dredge in Redwharfe Bay, and during "Mavis" expedition, 15 miles off Southport. Also more recently in April, 1893, during a dredging expedition in "Lady Loch" when I found numbers of this species in washings from dredgings taken off Port Erin at a depth of 20 fathoms.

Artotrogus boeckii, Brady. (Pl. XXV, fig. 2.)

Length 1.30 mm. Dredged off the Calf of Man in 20 fathoms.

Artotrogus magniceps, Brady. (Pl. XXVI, fig. 3.)

Length 1.25 mm. Dredged off the Calf of Man, and the Little Orme, and taken in townet off Puffin Island.

Artotrogus normani, Brady & Robertson. (Pl. XXVI, fig. 5.)

Length 1.25 mm. A single specimen was dredged off the Calf of Man in 20 fathoms.

Artotrogus orbicularis, Boeck. (Pl. XXVI, fig. 4.)

Length 1.65 mm. A single specimen of this beautiful and striking copepod was found by Prof. Herdman underneath a stone on the spit at Puffin Island. Though diligently searched for we have never succeeded in finding another.

Acontiophorus scutatus, Brady & Rob. (Pl. XXVI, fig. 8.)

Length 0.80 mm. A few specimens have been found in rock pools at Hilbre and Puffin Islands.

Family Chondracanthidæ.

Lernentoma lophii, Johnston. (Pl. XXVII, fig. 1.)

Numerous specimens of this species were recently found by Mr. Corbin adherent to Cod, Ling and Lophius taken off Barrow. The female is from $\frac{1}{4}$ to $\frac{1}{2}$ an inch or more in length and is adorned with numerous blunt spines or tubercles over the surface of the body. The oviferous tubes are very long, slender and twisted. The males of this genus are very small and rudimentary, living parasitically on the body of the female.

Family Caligidæ.

Caligus rapax, M. Edwards. (Pl. XXVII, fig. 4.)

Length 4.50 mm. This species is common throughout the district, being frequently taken at night by the townet

as a free swimmer, and is often found parasitic upon the cod and other fishes.

Caligus curtus, Leach. (Pl. XXVII, fig. 3.)

Length 5.0 mm. Less common than the preceding species, but found under similar conditions and attached to the cod and plaice. The conspicuous lunules or sucking discs situated on the lower surface of the frontal plates and having the appearance of eyes distinguish the genus Caligus from the rest of the family Caligidæ.

Lepeoptheirus stromii, Baird. (Pl. XXVII, fig. 6. *b*.)

Length 2.50 mm.

Lepeoptheirus nordmannii, M. Edw. (Pl. XXVII, fig. 5. *a*.)

Length 4.50 mm.

Lepeoptheirus hippoglossi, Kroyer. (Pl. XXVII, fig 6. *a*.)

Length 4.50 mm.

Lepeoptheirus obscurus, Baird. (Pl. XXVII, fig. 5. *b*.)

Length 2.60 mm. All the specimens I have received of the above four species of the genus *Lepeoptheirus* were sent to me from Bull Bay by the late Mr. Frank Archer who had obtained them from the local fishermen.

Family Lernæidæ.

Lernæa branchialis, Linn. (Pl. XXVI, fig. 7.)

Two very minute Crustacea (fig. 1) were taken in the tow-net off Puffin Island, which appeared to be larval forms of a *Lernæa*. Since then two more highly developed specimens (one from the same locality) have been found, apparently belonging to the same species as the larval specimens. They agree in the main with *Lernæa branchialis*, Linn., described and figured by Claus in his "Beobachtungen ueber Lernæocera, Penicillus und Lernæa, 1868," corresponding in most particulars with the male and female described by Claus, and I have provisionally included them under this species. Our specimens differ

from those figured by Claus chiefly in the form of the prehensile posterior antennæ and in the segmentation of the abdomen; but this animal appears to vary much in these very particulars according to age and sex, and it is therefore quite likely that Claus's specimens may represent slightly different stages of development. The group is extremely interesting, as exhibiting progressive and retrogressive development, and deserves more attention than it appears to have hitherto received. The female is about 1-18th inch in length, the male rather smaller, and the larval form about half the size of the female.

Since the above were recorded Prof. Herdman has found a number of adult specimens of *Lernæa branchialis* adherent to the gills of whitings taken in the Rock Channel.

Family LERNÆOPODIDÆ.

Anchorella uncinata, Müller. (Pl. XXVII, fig. 2.)

Length (without ovaries) 2.20 mm. Several specimens were found by Mr. Corbin on the gills of whiting taken in the Mersey estuary. Microscopical examination of one of them in situ shows the parasite impaled by the rounded knob at end of arms to one of the clusters of gill rakers which occurs at regular intervals along the concave side of the branchial arches. These rakers serve to arrest the passage of any solid substances into the gill cavities and appear also to form a secure anchorage for parasites which in *Anchorella* are surrounded by a tough transparent membrane. There are no males among those I have examined.

EXPLANATION OF PLATES.

PLATE XV.

Fig. 1. *Calanus finmarchicus*, Gunner. *a*, Rostrum, *b*, terminal spine of swimming feet.

Fig. 2. *Metridia armata*, Boeck. *a*, terminal spine of swimming feet. *b*, fifth foot of male. *c*, fifth foot of female.

Fig. 3. *Pseudocalanus elongatus*, Baird. *a*, Posterior antenna. *b*, fifth pair of feet of male.

Fig. 4. *Pseudocalanus armatus*, Boeck. *a*, Foot of second pair. *b*, foot of fifth pair of male.

Fig. 5. *Paracalanus parvus*, Claus. *a*, termination of swimming feet. *b*, fifth foot of male. *c*, fifth foot of female.

Fig. 6. *Acartia clausii*, Giesbrecht. *a*, terminal spine of swimming feet. *b*, fifth foot of female. *c*, Caudal segments of *Acartia discaudatus*.

Fig. 7. *Temora longicornis*, Müller. *a*, terminal spine of swimming feet. *b*, caudal segments.

Fig. 8. *Eurytemora clausii*, Boeck. *a*, terminal spine of swimming feet. *b*, fifth foot of female.

Plate XVI.

Fig. 1. *Eurytemora affinis*, Poppe. *a*, anterior antenna of male. *b*, fifth foot of female.

Fig. 2. *Isias clavipes*, Boeck. *a*, fifth foot of male. *b*, fifth foot of female.

Fig. 3. *Centropages hamatus*, Lilljeborg. Fifth foot of male. *a*, terminal spine of swimming feet.

Fig. 4. *Parapontella brevicornis*, Lubbock. *a*, fifth pair of feet of male. *b*, fifth foot of female. *c*, Abdomen of male.

Fig. 5. *Labidocera wollastoni*, Lubbock. *a*, anterior antenna of male. *b*, right foot of fifth pair of male. *c*, left foot of fifth pair of male. *d*, fifth pair of feet of female.

Fig. 6. *Labidocera acutum*, Dana. *a*, fifth pair of feet of male. *b*, fifth foot of female. *c*, abdomen and

posterior thoracic angles of male. *d*, abdomen and posterior thoracic angles of female.

Fig. 7. *Anomalocera patersonii*, Templeton.

Fig. 8. *Euchæta marina*, Prestandrea. *a*, posterior antenna.

Plate XVII.

Fig. 1. *Oithona similis*, Claus.

Fig. 2. *Cyclopina littoralis*, Brady. *a*, posterior antenna. *b*, mandible and palp. *c*, fifth foot.

Fig. 3. *Cyclopina gracilis*, Claus. *a*, posterior antenna. *b*, mandible and palp. *c*, anterior foot jaw. *d*, posterior foot jaw.

Fig. 4. *Thorellia brunnea*, Boeck. *a*, posterior antenna. *b*, mandible and palp. *c*, posterior foot jaw. *d*, last thoracic segment with fifth feet and first two abdominal segments.

Fig. 5. *Hersiliodes puffini*, Thompson. *a*, anterior antenna. *b*, mandible. *c*, one of fifth feet.

Fig. 6. *Giardella callianassæ*, Canu. *a*, posterior antenna. *b*, one of fifth feet.

Fig. 7. *Notodelphys allmani*, Thorell. *a*, posterior antenna. *b*, one of fifth feet.

Fig. 8. *Doropygus pulex*, Thorell. *a*, female. *b*, male.

Plate XVIII.

Fig. 1. *Doropygus poricauda*, Brady. *a*, posterior antenna. *b*, one of fifth feet.

Fig. 2. *Doropygus gibber*, Thorell. *a*, posterior antenna. *b*, one of fifth feet.

Fig. 3. *Botachus cylindratus*, Thorell. *a*, male. *b*, female.

Fig. 4. *Ascidicola rosea*, Thorell. *a*, mandible and palp.

Fig. 5. *Notopterophorus papilio*, Hesse. *a*, side view, male. *b*, dorsal view, male.

Fig. 6. Ventral view, female.

Fig. 7. *Longipedia coronata*, Claus.

Fig. 8. *Ectinosoma spinipes*, Brady. *a*, first foot jaw. *b*, second foot jaw. *c*, *Ectinosoma erythrops*, Brady, first foot jaw. *d*, second foot jaw. *e*, *Ectinosoma curticorne*, Boeck, fifth foot.

Plate XIX.

Fig. 1. *Ectinosoma atlanticum*, Brady and Robertson. *a*, anterior antenna, female. *b*, posterior antenna. *c*, anterior foot jaw. *d*, posterior foot jaw.

Fig. 2. *Tachidius littoralis*, Poppe. *a*, anterior antenna, male. *b*, posterior antenna. *c*, posterior foot jaw. *d*, fifth pair of feet, female. *e*, *Tachidius brevicornis*, Müller, antenna of female.

Fig. 3. *Euterpe gracilis*, Claus, male. *a*, anterior antenna, female. *b*, posterior antenna. *c*, fifth foot, male. *d*, fifth foot, female.

Fig. 4. *Robertsonia tenuis*, Brady and Robertson, female. *a*, anterior antenna, male. *b*, posterior antenna. *c*, posterior foot jaw. *d*, fifth foot, female.

Fig. 5. *Amymone sphærica*, Claus, male. *a*, mandible and palp. *b*, *Amymone longimana*, Claus, posterior foot jaw.

Fig. 6. *Stenhelia hispida*, Brady, female. *a*, posterior foot jaw. *b*, second foot of male. *c*, fifth foot of female.

Fig. 7. *Ameira longipes*, Boeck, female. *a*, anterior antenna, female. *b*, anterior antenna, male. *c*, posterior foot jaw. *d*, fifth foot, female.

Fig. 8. *Jonesiella fusiformis*, Brady and Robertson. *a*, anterior antenna, female. *b*, *Bradya typica*, Boeck, anterior antenna, female. *c*, tail.

Plate XX.

Fig. 1. *Jonesiella hyænæ*, Thompson, female. *a*, posterior antenna. *b*, anterior foot jaw. *c*, posterior foot jaw. *d*, fifth foot, female.

Fig. 2. *Delavalia palustris*, Brady, male. *a*, anterior antenna, female. *b*, foot of first pair.

Fig. 3. *Delavalia reflexa*, Brady and Robertson, female. *a*, posterior foot jaw. *b*, fifth foot.

Fig. 4. *Mesochra lilljeborgii*, Boeck, female. *a*, anterior antenna, female. *b*, anterior antenna, male. *c*, posterior foot jaw. *d*, fifth foot, female.

Fig 5. *Diosaccus tenuicornis*, Claus. *a*, anterior antenna, female. *b*, first foot. *c*, fifth foot, female.

Fig. 6. *Laophonte serrata*, Claus, male. *a*, anterior antenna, female. *b*, posterior antenna. *c*, posterior foot jaw. *d*, mandible and palp.

Fig. 7. *Laophonte horrida*, Norman, female. *a*, dorsal view. *b*, lateral view. *c*, posterior foot jaw. *d*, first foot. *e*, fifth foot, female.

Fig. 8. *Laophonte lamellifera*, Claus. *a*, anterior antenna, female. *b*, posterior foot jaw. *c*, fifth foot, female. *d*, tail.

Plate XXI.

Fig. 1. *Misophria pallida*, Boeck. *a*, anterior antenna, female. *b*, posterior antenna. *c*, mandible and palp.

Fig. 2. *a*, *Ectinosoma melaniceps*, Boeck, second foot jaw. *b*, *Tachidius brevicornis*, Müller, fifth feet, female. *c*, fifth foot, male. *d*, *Stenhelia ima*, Brady, second foot jaw. *e*, fifth foot, female. *f*, one of tail segments.

Fig. 3. *Laophonte curticauda*, Boeck, female. *a*, anterior antenna, female. *b*, posterior antenna. *c*, pos-

terior foot jaw. *d*, Inner branch of second foot, male.

Fig. 4. *Laophonte hispida*, Brady and Robertson. *a*, anterior antenna, female. *b*, posterior foo jaw. c, one of caudal segments. *d*, fifth foot.

Fig. 5. *Laophonte similis*, Claus. *a*, anterior antenna. *b*, fifth foot, female. *c*, fifth foot, male. *d*, appendages of first abdominal segment. *e*, *Laophonte thoracica*, Boeck, anterior antenna. *f*, posterior foot jaw. *g*, fifth foot.

Fig. 6. *Normanella dubia*, Brady and Robertson. *a*, anterior antenna, female. *b*, mandible. *c*, posterior foot jaw. *d*, first foot.

Fig. 7. *Cletodes limicola*, Brady. *a*, anterior antenna, female. *b*, anterior antenna, male. *c*, posterior antenna. *d*, fifth foot, female. *e*, fifth foot, male.

Fig. 8. *Cletodes linearis*, Claus. *a*, anterior antenna, female. *b*, posterior foot jaw. *c*, inner branch of posterior antenna. *d*, outer branch of foot of third pair, male. *e*, fifth foot, male. *f*, *Cletodes longicaudata*, Brady and Robertson, caudal segments.

Plate XXII.

Fig. 1. *Enhydrosoma curvatum*, Brady and Robertson. *a*, anterior antenna, female. *b*, anterior antenna, male. *c*, posterior antenna. *d*, anterior foot jaw. *e*, posterior foot jaw. *f*, fifth pair of feet.

Fig. 2. *Platychelipus littoralis*, Brady. *a*, anterior antenna, female. *b*, anterior antenna, male. *c*, posterior foot jaw. *d*, foot of first pair.

Fig. 3. *Dactylopus tisboides*, Claus. *a*, posterior antenna. *b*, first foot. *c*, fifth foot, female.

Fig. 4. *a*, *Dactylopus stromii*, Baird, anterior antenna, female. *b*, inner branch of second foot, male. *c*, *Dactylopus tenuiremis*, Brady and Robertson, anterior antenna, male. *d*, one of tail segments. *e*, *Dactylopus brevicornis*, Claus, anterior antenna, female. *f*, second foot jaw. *g*, fifth foot, female.

Fig. 5. *Dactylopus flavus*, Claus. *a*, anterior antenna, female. *b*, fifth foot, male. *c*, fifth foot, female. *d*, caudal segments, female. *e*, *Dactylopus minutus*, Claus, anterior antenna, female.

Fig. 6. *Thalestris rufocincta*, Norman. *a*, one of swimming feet, showing aculeate spines. *b*, *Thalestris clausii*, Norman, first pair swimming feet. *c*, posterior foot jaw.

Fig. 7. *Thalestris helgolandica*, Claus. *a*, anterior antenna, male. *b*, posterior antenna. *c*, fifth pair of feet, female.

Fig. 8. *Thalestris harpactoides*, Claus. *a*, anterior antenna, female. *b*, anterior antenna, male. *c*, posterior antenna. *d*, posterior foot jaw. *e*, fifth foot, female.

Plate XXIII.

Fig. 1. *Thalestris rufo-violescens*, Claus. *a*, anterior antenna, female. *b*, posterior antenna. *c*, posterior foot jaw. *d*, fifth foot, female.

Fig. 2. *a*, *Thalestris serrulata*, Brady, caudal segments. *b*, *Thalestris hibernica*, Brady and Robertson, anterior antenna. *c*, inner branch, posterior antenna. *d*, posterior foot jaw. *e*, fifth foot, female. *f*, fifth foot, male.

Fig. 3. *Thalestris longimana*, Claus. *a*, fifth foot, female. *b*, fifth foot, male. *c*, *Thalestris peltata*, Boeck,

anterior antenna, rostrum, and eye spot, female. *d*, fifth foot, female.

Fig. 4. *Westwoodia nobilis*, Baird. *a*, posterior antenna. *b*, posterior foot jaw. *c*, first foot.

Fig. 5. *Harpacticus chelifer*, Müller. *a*, inner branch of posterior antenna. *b*, spine of posterior antenna. *c*, posterior foot jaw. *d*, fifth pair of feet.

Fig. 6. *a*, *Harpacticus fulvus*, Fischer. Inner branch of second foot, male. *b*, posterior foot jaw. *e*, first foot. *d*, *Harpacticus flexus*, Brady and Robertson, posterior foot jaw. *c*, inner branch of second foot, male. *f*, fifth foot, female.

Fig. 7. *Zaus spinatus*, Goodsir. *a*, anterior antenna, male. *b*, posterior antenna. *c*, mandible and palp. *d*, foot of fifth pair, female.

Fig. 8. *Zaus goodsiri*, Brady. *a*, posterior foot jaw. *b*, fifth foot, female.

Plate XXIV.

Fig. 1. *Alteutha interrupta*, Goodsir. *a*, anterior antenna, male. *b*, fifth foot. *c*, *Alteutha depressa*, Baird, anterior antenna, male. *d*, fifth foot.

Fig. 2. *Alteutha crenulata*, Brady. *a*, anterior antenna, female. *b*, anterior antenna, male. *c*, posterior foot jaw. *d*. foot of fifth pair, male, and angle of first abdominal segment.

Fig. 3. *Porcellidium tenuicauda*, Claus. *a*, *Porcellidium viride*, Philippi, fifth pair of feet, abdomen, and tail of male.

Fig. 4. *Idya furcata*, Baird. *a*, posterior antenna. *b*, foot of first pair. *c*, fifth foot, female.

Fig. 5. *Scutellidium tisboides*, Claus. *a*, first foot. *b*, anterior foot jaw. *c*, posterior foot jaw. *d*, *Scutellidium fasciatum*, Boeck, anterior foot jaw.

e, posterior foot jaw. *f*, fifth foot, female.

Fig. 6. *Monstrilla rigida*, Thompson. *a*, anterior antenna, male. *b*, *Monstrilla danæ*, Claparède, abdomen and caudal segments.

Fig. 7. *Monstrilla anglica*, Lubbock. *a*, anterior antenna, male. *b*, feathery plume on apical segment.

Fig. 8. *Monstrilla longicornis*, Thompson. *a*, anterior antenna, male. *b*, genital appendage on first abdominal segment of *M. anglica*, male.

Plate XXV.

Fig. 1. *Lichomolgus fucicolus*, Brady. *a*, posterior antenna. *b*, posterior foot jaw of male. *c*, posterior foot jaw of female. *d*, fourth foot.

Fig. 2. *Lichomolgus liber*, Brady and Robertson. *a*, foot of fifth pair. *b*, abdomen of male. *c*, *Lichomolgus thorellii*, Brady and Robertson, abdomen and tail of female.

Fig. 3. *Lichomolgus furcillatus*, Thorell. *a*, anterior antenna, female. *b*, mandible. *c*, *Lichomolgus albens*, Thorell. Abdomen, tail, and fifth feet.

Fig. 4. *Lichomolgus agilis*, Scott. *a*, anterior antenna, female. *b*, posterior foot jaw, male. *c*, posterior foot jaw, female. *d*, foot of fourth pair.

Fig. 5. *Sabelliphilus sarsii*, Claparède. *a*, anterior antenna, female. *b*, posterior antenna. *c*, posterior foot jaw. *d*, foot of fifth pair.

Fig. 6. *Cylindropsyllus lævis*, Brady. *a*, anterior antenna, female. *b*, posterior antenna. *c*, foot of fifth pair, female. *d*, foot of fifth pair, male.

Fig. 7. *Cyclopicera nigripes*, Brady and Robinson. *a*, anterior antenna, female. *b*, posterior antenna. *c*, posterior foot jaw. *d*, fifth foot, female.

Fig. 8. *Cyclopicera lata*, Brady. *a*, abdomen and fifth feet, female. *b*, anterior antenna, female. *c*, posterior antenna. *d*, *Lichomolgus agilis*. Scott.

Plate XXVI.

Fig. 1. *Cyclopicera gracilicauda*, Brady. *a*, posterior antenna. *b*, anterior foot jaw. *c*, posterior foot jaw. *d*, fifth foot.

Fig. 2. *Artotrogus boeckii*, Brady. *a*, posterior antenna. *b*, posterior foot jaw. *c*, maxilla. *d*, fifth foot.

Fig. 3. *Artotrogus magniceps*, Brady. *a*, anterior antenna. *b*, anterior foot jaw. *c*, posterior foot jaw. *d*, foot of fifth pair.

Fig. 4. *Artotrogus orbicularis*, Boeck.

Fig. 5. *Artotrogus normani*, Brady and Robertson. *a*, anterior antenna. *b*, pittings on shell. *c*, posterior antenna. *d*, posterior foot jaw.

Fig. 6. *Dyspontius striatus*, Thorell. *a*, anterior antenna. *b*, posterior foot jaw. *c*, abdomen of female.

Fig. 7. *Lernæa branchialis*, Linn. *a*, adult male. *b*, adult female.

Fig. 8. *Acontiophorus scutatus*, Brady and Robertson. *a*, anterior antenna, female. *b*, posterior antenna. *c*, fifth foot, female.

Plate XXVII.

Fig. 1. *Lernentoma lophii*, Johnston.

Fig. 2. *Anchorella uncinata*, Müller.

Fig. 3. *Caligus curtus*, Leach.

Fig. 4. *Caligus rapax*, Mln. Edwards.

Fig. 5. *a*, *Lepeoptheirus normanni*, Mln. Edw. *b*, *Lepeoptheirus obscurus*.

Fig. 6. *a*, *Lepeoptheirus hippoglossi*, Kroyer. *b*, *Lepeoptheirus stromii*, Baird.

Fig. 7. *a*, *Cervinia bradyi*, Norman. *b*, anterior antenna. *c*, posterior antenna. *d*, foot of second pair. *e*, foot of fifth pair.

Fig. 8. *a*, *Paramesochra dubia*, Scott, female. *b*, *Tetragoniceps bradyi*, Scott, anterior antenna, female. *c*, abdomen, female. *d*, foot of fifth pair, male. *e*, caudal stylet, female. *f*, caudal stylet, male.

Plate XXVIII.

Fig. 1. *Herdmania stylifera*, n. sp., female.

Fig. 2. Anterior antenna, female.

Fig. 3. ,, male.

Fig. 4. Posterior antenna.

Fig. 5. Mandible and palp.

Fig. 6. Maxilla.

Fig. 7. First foot jaw.

Fig. 8. First foot.

Fig. 9. Third foot.

Fig. 10. Fourth foot.

Fig. 11. Fifth foot, female.

Fig. 12. ,, male.

Plate XXIX.

Fig. 1. *Cyclops marinus*, n. sp., female.

Fig. 2. Anterior antenna.

Fig. 3. Posterior antenna.

Fig. 4. Mandible and palp.

Fig. 5. Maxilla.

Fig. 6. Anterior foot jaw.

Fig. 7. Posterior foot jaw.

Fig. 8. Foot of first pair.

Fig. 9. Fifth pair of feet and abdomen

Plate XXX.

Fig. 1. *Stenhelia denticulata*, n. sp., female.
Fig. 2. Anterior antenna.
Fig. 3. Posterior antenna.
Fig. 4. Mandible and palp.
Fig. 5. Maxilla.
Fig. 6. Anterior foot jaw.
Fig. 7. Posterior ,,
Fig. 8. Foot of first pair.
Fig. 9. Foot of third pair.
Fig. 10. Foot of fifth pair.
Fig. 11. Caudal segments.

Plate XXXI.

Fig. 1. *Stenhelia hirsuta*, n. sp., female.
Fig. 2. Anterior antenna, female.
Fig. 3. Anterior antenna, male.
Fig. 4. Posterior antenna.
Fig. 5. Mandible and palp.
Fig. 6. Maxilla.
Fig. 7. First foot jaw.
Fig. 8. Second foot jaw.
Fig. 9. Foot of first pair.
Fig. 10. Inner branch of second foot, male
Fig. 11. Foot of third pair.
Fig. 12. Fifth foot, female.
Fig. 13. Fifth foot, male.

Plate XXXII.

Fig. 1. *Ameira attenuata*, n. sp., female.
Fig. 2. ,, ,, male
Fig. 3. Anterior antenna, female.
Fig. 4. ,, male.
Fig. 5. Posterior antenna.

Fig. 6. Second foot jaw.
Fig. 7. Foot of first pair.
Fig. 8. ,, third pair.
Fig. 9. ,, fifth pair, female.
Fig. 10. ,, ,, male.
Fig. 11. Caudal segments.

Plate XXXIII.

Fig. 1. *Laophonte spinosa*, n.sp., male.
Fig. 2. Anterior antenna.
Fig. 3. ,, female.
Fig. 4. Posterior antenna.
Fig. 5. Mandible and palp.
Fig. 6. Maxilla.
Fig. 7. Second foot jaw.
Fig. 8. First foot.
Fig. 9. Third foot.
Fig. 10. Fourth foot.
Fig. 11. Fifth foot, male.
Fig. 12. ,, female.
Fig. 13. One of caudal segments.

Plate XXXIV.

Fig. 1. *Cletodes monensis*, n. sp., female.
Fig. 2. Anterior antenna, and dorsal anterior end of cephalothorax.
Fig. 3. Posterior antenna.
Fig. 4. Maxilla.
Fig. 5. Mandible and palp.
Fig. 6. Anterior foot jaw.
Fig. 7. Posterior foot jaw.
Fig. 8. Foot of first pair.
Fig. 9. Foot of fourth pair.
Fig. 10. Fifth pair of feet.
Fig. 11. Caudal stylets.

Plate XXXV.

Fig. 1. *Lichomolgus maximus*, n. sp., male.
Fig. 2. ,, ,, female.
Fig. 3. Anterior antenna.
Fig. 4. Posterior antenna.
Fig. 5. Mandible and palp.
Fig. 6. Anterior foot jaw.
Fig. 7. Posterior foot jaw, male.
Fig. 8. ,, ,, female.
Fig. 9. Foot of first pair.
Fig. 10. Foot of fourth pair.
Fig. 11. Foot of fifth pair.

Alphabetical Index to Species.

[WORK FROM THE PORT ERIN BIOLOGICAL STATION.]

NOTES on the HÆMAL and WATER-VASCULAR SYSTEMS of the ASTEROIDEA.

BY HERBERT C. CHADWICK.

With Plates XXXVI to XXXIX.

[Read 10th March, 1893.]

EIGHTEEN months ago, at the suggestion of Prof. Milnes Marshall of Owens College, I undertook a re-examination of the structures which together form what is commonly known as the blood-vascular system of the Asteroidea. To those who are acquainted with the literature of the Echinodermata, especially that published during the past twelve or fifteen years, such a research may, at first sight appear quite superfluous, the structures just named having been described by Ludwig, Perrier, Hamann, Cuénot, and quite recently by Durham. I was, however, fully aware that a certain amount of scepticism existed in the minds of other workers in the same field, as to the accuracy of the descriptions given by one or other of these zoologists, and on that account was not unwilling to examine some of the doubtful points for myself. Though not yet quite complete, my work is sufficiently far advanced to warrant my acceptance of the invitation of the Council of the Liverpool Biological Society to submit my results for the consideration of its members. The close anatomical relation in which the so-called blood-vascular system stands to the water-vascular system has led me to a study of the latter scarcely less detailed than that of the former, and for convenience sake I shall discuss the two systems together.

My thanks are due to Prof. Marshall for placing at my disposal the resources of the Owens College Zoological Laboratory, and for his ever ready kindness and advice; also to Mr. R. Standen of the same Laboratory, for the readiness and goodwill with which he has assisted me in the preparation of my material, nearly the whole of which has been collected at various points within the marine area of the Liverpool Marine Biology Committee. To that Committee my thanks are tendered for the facilities afforded by the Marine Biological Station at Port Erin for the examination and preservation of the material collected in that neighbourhood. With regard to methods of preservation, I must admit that mine have not been in error on the side of refinement. Previous experience of the slowness with which osmic acid penetrates, and the brittleness which it produces, led me to neglect the use of this otherwise valuable re-agent. In nearly every case my specimens were fixed with saturated solution of corrosive sublimate, care being taken to expose well the parts required for sectioning. Decalcification was effected by immersion in 10 °/° solution of nitric acid for about 24 hours, more or less according to the size of the specimen. In one case I put the living starfish, after severing the rays from the disc, into the nitric acid solution, and hardened it in alcohol afterwards. This method is not without its value on account of the extremely small amount of contraction produced. Before discussing the results of my own work and that of my predecessors, I propose to give a brief account of the hæmal* and water-vascular systems of the Asteroidea, and of such other structures as are in relation thereto. In this way I hope to make the

* Agreeing with Durham I regard this term as more appropriate than "blood vascular."

following account of the structures upon which my interest has been chiefly centred more intelligible.

The majority of the Asteroidea assume the form of a five-rayed star, but in some few genera (*Solaster*, *Brisinga*) the rays are more numerous. Other genera (*Asterina*, *Porania*) are pentagonal. Except in *Brisinga*, a form which has not yet been found in our area, the rays are not sharply marked off from, but are continuous with the central disc. The oral face of each ray presents a deep groove, the ambulacrum, in which the tube feet are lodged. The mouth always occupies the centre of the ventral surface of the disc, and is surrounded by a membranous peristome. It opens directly into a capacious stomach, divided by a deep constriction into a wide cardiac and a shallow pyloric portion. The walls of the former extend a short distance into the cavity of the rays as cardiac sacs. The pyloric portion is, in the five-rayed species, of pentagonal form, the angles of the pentagon being radial. Tubular prolongations of the pylorus arise at each angle, and entering the rays, from the aboral walls of which they are suspended by mesenteric folds, each one divides into two parallel and densely sacculated portions which terminate blindly near the tips of the rays. An aperture in the centre of the aboral face of the pylorus, closed by valvular folds, opens into a very short and inconspicuous intestine, which has in connection with it a lobulated cæcum. In some species a minute anal pore opens upon the aboral face of the disc.

What I have already referred to as the hæmal system consists of an elongated plexiform body, often spoken of as the heart (Pl. XXXVIII, fig. 2; Pl. XXXIX, fig. 1, *c.pl.*), which lies in close proximity to the water tube (*wt*), and communicates with similarly constituted circum-oral (*cohr*) and aboral (*ahr*) rings. From the former plexiform

strands traverse the rays (*rhs*), while the latter gives origin to similar strands which are distributed to the genital glands (*gs*). There are also two strands which pass from the central plexus to the pyloric portion of the gut (*ghs*). On the aboral face of the disc, between the origins of two of the rays, is a rounded or pentagonal, more or less convex plate, the madreporite (Pl. XXXVIII, fig. 2, *m*). Its surface is traversed by meandering grooves, radiating from the centre. Numerous perforations through its substance (Pl. XXXVI, figs. 1 and 2; Pl. XXXIX, fig. 1, *mp*) conduct the surrounding water into a tubular canal, supported by ring-like ossicles lodged within its walls, the water-tube or stone-canal (Pl. XXXVIII, fig. 2; Pl. XXXIX, fig. 1, *wt*).

Passing downwards towards the oral aspect, the water-tube opens into a pentagonal vessel which surrounds the mouth, the circum-oral water vessel. (Pl. XXXVIII, figs. 1 and 2; Pl. XXXIX, fig. 1, *cowv*). In *Astropecten* and *Luidia* five pairs of glandular cæca, the "brown bodies" of Tiedemann (*bb*) are seated, interradially, upon the inner border of the circum-oral water vessel, and communicate with its cavity. In *Asterias* and *Solaster* one of these bodies is absent from the madreporic interradius. The circum-oral water vessel has also communicating with it a number of sacs with muscular walls, the Polian vesicles (Pl. XXXVIII, fig. 1, *pv*). These open upon its outer border, immediately opposite the brown bodies, and are, therefore, interradial. In *Astropecten* and *Solaster* the Polian vesicles are large and pear shaped, while those of *Asterias* are small and inconspicuous. From the circum-oral water vessel, vessels corresponding in number with that of the rays radiate (Pl. XXXVIII, figs. 1 and 2, *rwv*) and traversing the oral aspect of its ray, immediately external to the conjoined inner ends of the ambulacral

ossicles each one gives off on either side a great number of lateral branches which open into the cavities of the tube-feet. The fluid which occurs in these vessels contains amœboid corpuscles. Of the tube-feet there are two usually straight, but in *Asterias* sharply zig-zaged rows, lodged in the ambulacral grooves. Each tube-foot is provided with a vesicular ampulla lodged within the cavity of the ray. Communication between the two is established by a canal which passes upwards from the base of the foot through a corresponding pore formed by grooves in the two adjacent ambulacral ossicles. In many genera the tube-feet terminate in sucker-discs, but those of *Astropecten* and *Luidia* are conical at their free ends.

The nervous system consists of a plexus of nerve fibrils and ganglion cells which underlies the ectoderm. At the bottom of the ambulacral grooves the fibres are much more numerous, and run parallel with the axis of the ray. In transverse sections they appear as minute dots between the filiform inner ends of the ectoderm cells, which are here enormously elongated, and form a ridge-like thickening, the ambulacral nerve. Each radial nerve joins its fellows on either side to form the circum-oral nerve-ring (Pl. XXXVIII, figs. 1 and 3, *nr*). The generative organs consist of sacculated glands, of which there is a pair in each ray. Each gland is attached to the lateral wall of the ray, near its base, and opens by a single pore, or rarely by a number of pores. In the genus *Brisinga* each ray contains a number of distinct glands, arranged serially along each side of the ray, and opening by separate pores.

Having thus briefly surveyed the general organisation of starfishes, I now proceed to a discussion of the minute anatomy of the two systems mentioned at the outset. Careful examination of a large number of sections of the madreporite of *Asterias*, *Cribrella*, *Astropecten* and *Aste-*

rina has led me to support the view advanced by Tiedemann, Müller, Agassiz, and much more recently by Ludwig, viz., that all the pores which traverse this plate open directly into the water-tube (Pl. XXXVI, fig. 1, *mp*). Hoffmann, supported by Greeff and Teuscher held on the other hand that some of the marginal pores open into the cœlom, and others into the axial perihæmal canal. A condition of things differing from either of the latter is presented by one of my series of sections, cut from the disc, 6 mm. in diameter, of a specimen of *Asterias rubens*. In this three or four of the madreporic pores opens directly into the lacunar system of the body-wall (Pl. XXXVI, fig. 2). In young specimens of *Cribrella*, 2 mm. in diameter, Durham (1) found but a single pore opening into the cavity of the axial perihæmal canal, into which the water-tube also opens; and Cuénot (2) shows that in some species this state of things may continue throughout life.

Communicating with the exterior through one of the madreporic pores in the specimen just alluded to is an elongated glandular structure, lodged in one of the lacunæ of the body wall (Pl. XXXVI, fig. 2, *gb*). It is composed entirely of small rounded cells with comparatively large nuclei, and does not present any cavity or lumen. I am not at present able to offer an opinion as to whether this organ should be regarded as an example of the structure described by Greeff and Ludwig, and alluded to by Carpenter (3) as a diverticulum of the water-tube, or as an independent and perhaps hitherto undescribed structure. It is certainly independent of the water-tube, through lying in close proximity to it. Still more perplexing is its occurrence in only one specimen out of a dozen carefully examined. In its passage downwards to the oral aspect of the disc, the water-tube is supported by the free edge of a projecting fold formed by the junction of the rays on

either side of the madreporic interradius, and this fold encloses a cavity known as the axial perihæmal canal (Pl. XXXVII, figs. 1, 2 and 4; Pl. XXXIX, fig. 1, *ax. pc*). Within the perihæmal canal, and supported by its wall lies the dorsal organ, or, as I prefer to call it, the central plexus (*cpl*).

Discovered long ago by Spix, the central plexus and its homologue in other groups of the Echinodermata has been repeatedly described, and its function speculated upon. Tiedemann, with a nearer approach to what I believe to be the truth than some of his successors, regarded it as a heart. Greeff described it as a gill-like organ, Hoffmann, a little latter propounding a view which still has its adherents, viz., that it is a glandular body. Later still Teuscher, followed by Ludwig, revived Tiedemann's view that it is a heart, but in his later papers Ludwig discards the term "heart" substituting for it the more appropriate term "central plexus." The organ presents a very similar appearance in the four genera of Asteroidea in which I have examined it. In young specimens of *Asterias rubens*, whose discs measure 3—4 mm. in diameter, it appears as a thickened band of undifferentiated cells, closely applied to the wall of the perihæmal canal (Pl. XXXVII, fig. 1, *cpl*). In very slightly larger specimens, however, I find it to have assumed the adult condition. At its aboral end it is more or less lobulated (Pl. XXXVIII, fig. 2), and occupies a considerable portion of the cavity of the perihæmal canal. Gradually tapering towards its oral end, it becomes continuous with an oblique perforated septum about which I shall have more to say shortly. Examined by means of thin sections the organ is seen to consist of anastomosing tubular strands, the walls of which appear in transverse sections as an exceeedingly thin membrane (Pl. XXXVII, fig. 2; see also the figures illustrating

Durham's paper, quoted above). In longitudinal sections fine fibrils may be seen, especially in the tapering oral end. The whole organ is densely crowded with small cells, similar as Durham remarks, to the leucocytes of the cœlomic fluid (Pl. XXXVII, fig. 3). Upon its surface, a number of clear vesicle-like spaces may be seen. These, in the opinion of the author just quoted, are points at which the fluid contained in the tubules is more abundant. Upon some of them the cells already mentioned form a reticulum by means of their pseudopodial processes (*x*). As far as I can make out there is no regular epithelium within or without the membranous wall of the tubules, such as is described and figured by Hamann (4). There certainly is such an epithelial lining within the tubules of the central plexus of *Antedon*; but in Crinoids the organ and its connections appear to me to be of a more highly specialised character than in Asterids. Allusion has already been made in the introductory part of this paper to the so-called gastric blood vessels, which are described as passing from the central plexus to the pyloric portion of the gut. I have had no difficuty in making out the intimate relation of these strands to the epithelial lining of the gut, (Pl. XXXVII, fig. 4; Pl. XXXIX, fig. 1, *ghs*) and, in the case of one of them, to the central plexus. The continuity of the other stand with the latter organ is, however, not so obvious, and though I have examined it carefully in all my series of sections I have not been able to arrive at a definite conclusion with regard to it. Whatever the true nature of these strands may be, they are certainly something more than "mesenteric bridles," under which term MacBride (5) alludes to their presence in Ophiurids.

At or near the point from which the gastric strand passes from the central plexus, the latter joins the aboral

hæmal ring (Pl. XXXVIII, fig. 2; Pl. XXXIX, fig. 1, *ahr*) from which arise the ten genital strands (*gs*), two at each interradius. Cuénot's (6) studies of the development of the genital organs of Asterids have led him to the conclusion that they are simply the largely developed ends of the genital strands, and that the cells of the strands give rise to ova or spermatoblasts. With the exception of the gastric strands, the whole hæmal system is enclosed in perihæmal canals, with which the axial perihæmal canal is continuous. I have already said that at its oral end the central plexus becomes continuous with an oblique perforated septum. This latter imperfectly separates the circum-oral perihæmal canals, into the inner of which the axial perihæmal canal opens, while the outer unites the perihæmal canals of all the rays (Pl. XXXIX, fig. 1, *ipc*, *opc*). Serial sections in which the septum appears show that at many points it presents lacunar spaces to which the term "oral blood-vascular ring" has been applied (Pl. XXXVIII, fig. 3, *cohr*), the lacunæ being described as vessels. They are, however, simply lacunar spaces, and except when distended with coagulum, or with amœboid cells, are not easy to see. It has been asserted that they and the hæmal lacunæ of the rays are nothing more than spaces occupied before decalcification of the specimen by calcareous skeletal matter. I am satisfied, however, that such is not the case, for the connective tissue basis upon which the skeleton is formed is always left intact after decalcification, and no such connective tissue is seen here. The perihæmal canals of the rays are, like the circumoral canals, imperfectly separated by a vertical septum which is continuous with the oblique septum already described. These also present lacunar spaces, frequently distended with coagulum, or with amœboid cells, and are the radial

bloods vessels of Ludwig and other authors (Pl. XXXIX, fig. 2).

Perrier and Poirier (7), followed by Cuénot, deny the existence of these radial hæmal strands; but the latter author admits that there is what he calls a "glandular" tract in the vertical septum, and figures one of the lacunar spaces. At regular intervals strands which appear in sections as oblique septa, and were described as such by Cuénot, pass from the radial hæmal strands to supply the tube-feet. The radial perihæmal canals are continuous, through the medium of lateral extensions passing between the tube-feet, with a system of lacunar spaces everywhere present in the body wall. I have already more than once referred to the existence of coagulum in the hæmal system. It is present at all points in larger or small quantities, the tubules of the central plexus frequently being much distended with it. Whether the fluid which gives rise to it merits the term blood or not may be open to question, but I am satisfied that it is a nutrient fluid, derived from the gut, and conveyed by the gastric hæmal strands to the central plexus, and from thence along the genital and radial strands. That such is its course is demonstrated by a series of sections cut from a young specimen of *Asterias rubens*, for which I am indebted to the kindness of Mr. W. Garstang. Into the stomach of the specimen in question, a number of very small cyst-like bodies, about $\frac{1}{5000}$th of an inch in diameter, and of a dark green colour, had found their way. Many of these had been ruptured, setting free large numbers of still smaller spore-like bodies, of which hundreds are now to be seen lodged between the bases of the epithelium cells lining the stomach, in the tubules of the gastric hæmal strands, and of the central plexus. Cuénot maintains that the true blood-fluid circulates in the perihæmal canals, but the very large number

of sections which I have examined lend no support to this view, there being no coagulum in these spaces. Here again my results confirm those of Durham. Besides being concerned in the distribution of nutrient material to the tissues the central plexus is, according to Cuénot, Prouho, and others, the seat of the production of the pigmented corpuscles which occur in the hæmal strands, in the vessels of the water vascular system, and in the cœlom. According to the first named author this function is also discharged by the brown bodies of Tiedemann and the Polian vesicles. However true this may be, I am not disposed to agree with his assertion that their histological structure is identical. The cells of which the tissue of Tiedemann's bodies is composed do appear to be similar to those of the central plexus, but the ramified tubules which together form the lumen of these bodies have a well defined epithelial lining of cuboid cells, continuous with that of the circum-oral water vessel.

Note on the histology of the tube feet:—

Some time ago, my attention was arrested by a statement on page 259 of Mr. G. J. Romanes' interesting little work entitled "Jelly-fish, Star-fish and Sea-urchins," to the effect that "each of the tube-feet is provided in its membranous walls with a number of annular or ring-shaped muscular fibres;" and a little further on that "if the contraction of these fibres is strong, the tube shrinks up entirely, i.e., is retracted within the body of the animal." On purely physical grounds the first of these statements seemed to me to be highly improbable; and being at the time unaware of the existence of Hamann's description and figures of the minute structure of these organs, I set to work to investigate the question for myself, with the result anticipated. The muscular fibres account for rather more than half the thickness of the tubular portion of the

tube-foot, and are separated from its cavity by a delicate lining of ill-defined epithelial cells. They are wholly longitudinal in every species examined. On approaching the terminal sucker (*Asterias, Solaster*) the fibres converge towards its centre, from which point they are distributed in beautifully regular radiating strands to its periphery. External to the muscular layer is (1) a layer of connective tissue; (2) a layer of nerve fibrils with ganglion cells; (3) an epithelial layer in which the cells are of considerable length, and consist of supporting cells, sensory cells, and gland cells, the latter occurring largely in the sucker; and (4) the structureless cuticle. It seems to me that contraction of annular fibres such as Romanes described would result rather in the extension of the tube-foot at the expense of its diameter, for a valvular arrangement prevents the reflux of the contained fluid from the tube-feet into the radial water-vessel. Extension is, moreover, brought about by the contraction of the ampullæ, while the longitudinal disposition of the muscular fibres is quite sufficient to account for all contractile movements. The second statement, with reference to complete retraction of the tube-feet within the body of the animal is entirely without foundation. Even after immersion in the strongest alcohol the tube-feet are never so retracted. The ectodermal and nerve layers are certainly thrown into numerous annular folds, and it is possible that a superficial examination of these led Mr. Romanes to describe them as annular muscles.

List of works referred to in the text.

1. Durham, H. E.—"On Wandering cells in Echinoderms, etc.," Quart. Journ. Micr. Sci., XXXIII, (1891).

2. Cuénot, L.—"Contributions à l'Etude anatomique des Astérides," 'Thèses prés. Fac. d. Sc.,' Paris, 1887.

3. Carpenter, P. H.—"The Minute Anatomy of the Brachiate Echinoderms," 'Quart. Journ. Micr. Sci., N.S., LXXXIII, (1881).'

4. Hamann, O.—'Histologie der Echinodermen,' I, II, III, IV. (Fischer, Jena).

5. MacBride, E. W.—"The Development of Amphiura squamata," 'Quart. Journ. Micr. Sci., XXXIV,' (1892).

6. Cuénot, L.—'Comptes Rendus.' CIV, (1887) pp. pp. 88—90.

7. Perrier, E. and Poirier, J.—'Comptes Rendus,' XCIV, (1882), pp. 658—61.

Explanation of Plates XXXVI to XXXIX.

List of reference letters.

ahr Aboral hæmal ring; *axpc* axial perihæmal canal; *bb* Tiedemann's bodies; *bm* buccal membrane; *cohr* circum-oral hæmal ring; *cowr* circum-oral water vessel; *cp* central plexus; *g* gut; *gb* glandular body; *ghs* gastric hæmal strands; *gs* genital strands; *int.m* interradial muscles; *ipc* inner perihæmal canal; *lac* lacunar spaces; *m* madreporite; *mp* madreporic pores; *nr* nerve ring; *oa* oral angles, *œ* œsophagus; *opc* outer perihæmal canal; *pv* Polian vesicles; *rhs* radial hæmal strands; *rwv* radial water vessel; *tf* tube-foot; *wt* water-tube; *x* vesicular spaces.

Plate XXXVI.

Fig. 1. Part of a horizontal section of a young *Asterias rubens*, showing the opening of the pore-canals of the madreporite into the water-tube.

Fig. 2. A similar section from a slightly older specimen. It passes through the periphery of the madreporite, and shows the opening of several pore-

canals into the lacunar system of the body-wall. The scale applies to both figures.

PLATE XXXVII.

Fig. 1. Horizontal section of the madreporic interradius of a young *Asterias rubens.*

Fig. 2. A similar section from an older specimen.

Fig. 3. Part (peripheral) of a tranverse section of the central plexus of an adult *Cribrella sanguinolenta.*

Fig. 4. A section similar to figs. 1 and 2 showing the relation of the gastric hæmal strands to the central plexus and the gut.

PLATE XXXVIII.

Fig. 1. Diagram of the central portions of the water-vascular and nervous systems of *Asterias rubens,* constructed from thirteen consecutive horizontal sections of the disc.

Fig. 2. Diagram of the central portions of the water-vascular and hæmal systems of *Asterias rubens,* constructed from several series of sections. Compare with Fig. 1, Plate XXXIX.

Fig. 3. Vertical section through the peristome of *Asterias rubens.* The scale applies to figs. 1 and 3.

PLATE XXXIX.

Fig. 1. Diagram of the central portions of the water-vascular and hæmal systems of *Asterias rubens,* constructed from ten consecutive sagittal sections through the madreporic interradius.

Fig. 2. Transverse section of the vertical septum which divides the radial perihæmal canals, showing four hæmal lacunæ. The dotted line in the upper ones represents coagulum.

Fig. 3. Longitudinal section of the oral end of the central plexus of *Asterias rubens.*

NOTE on SALENSKY'S account of the DEVELOPMENT of the STIGMATA in PYROSOMA,

By W. Garstang, M.A., F.Z.S.,

NATURALIST AT THE PLYMOUTH BIOLOGICAL STATION.

[Read 14th April, 1893.]

The concluding part of Salensky's valuable "Contributions to the Developmental History of *Pyrosoma*" (Spengel's Zool. Jahrbüch, Abth. f. Anat. u. Ont, vi, 1891) contains a curious inaccuracy, which although it offers little difficulty to those acquainted with the structure of *Pyrosoma* is likely to cause temporary confusion in the minds of many readers. Salensky, when dealing with the development of the stigmata, says (p. 32):—"Die kiemenspalten liegen der longitudinalen axe des embryos parallel und müssen also als longitudinale kiemenspalten bezeichnet werden. Da aber die Längsaxe des in der Entwicklung begriffenen Ascidiozoids der Queraxe des definitiven entspricht, so muss man die Längspalten eigentlich als die definitiven Querspalten betrachten:" *i.e.*, the stigmata in the embryo are parallel with the endostyle while in the adult they are elongated at right angles to it. In the same paper, however, three diagrams are given (p. 9) representing the chief stages in the development of an Ascidiozoid, "zur Erlaüterung des Textes." In the first of these diagrams (fig. 1) which represents an early stage in development, the stigmata are seen to be elongated *at right angles* to the endostyle and parallel with the transverse axis of the embryo; in the third (fig. 3)—which is supposed to represent the "ausgebildetes Ascidiozoid"—the stigmata are shewn *parallel* with the endostyle and with the longitudinal axis of the body; and fig. 2

represents a stage of development which is intermediate between the conditions shewn in figures 1 and 3. It is evident that the diagrams are not consistent with the statements made in the text. It is impossible to doubt the general accuracy of fig. 1, for it agrees with the figures of all other investigators, and is in accordance with the statements which they make. With regard to fig. 2, however, a comparison of it with Salensky's own camera drawing of the same stage (Pl. I, stage L, uppermost ascidiozoid) makes it clear that the stigmata of the former figure are represented by the internal longitudinal bars of the latter; in this diagram and in fig. 3, the mistake has been made of representing the stigmata as parallel with the endostyle when they ought to be at right angles to it.

I have elsewhere (Proc. Roy. Soc., LI, 1892, p. 506) briefly alluded to this error, but an abstract given by Professor Herdman in the recently published "Zoological Record for 1891" seems to indicate that the nature of the error has not been generally recognised and that it ought to be pointed out more fully. It would appear from the diagram in fig 2. that Salensky actually imagines that the endostyle alters its position quite independently of its anatomical relations to the other endodermic structures—the endostyle moving through an angle of 90° while the position of the stigmata remains unchanged. The well-known structure of the pharynx in the adult *Pyrosoma*, and the observations made by other investigators—especially Seeliger and Lahille—upon the relations of the endostyle and stigmata in the early stages of development form the basis for the alterations which have been suggested above; and I am not aware of any evidence which shews that the primary relation of the axes of endostyle and stigmata to one another is at any stage disturbed. Certain adaptive changes of form take place in the buds

of *Pyrosoma*, but they must not be mistaken for such an alteration in the relation of the axes of endostyle and stigmata to one another as that which has clearly occurred in certain species of *Doliolum* and in *Anchinia*.

I am not aware that Professor Salensky has anywhere referred to the inaccuracy I have mentioned above, but if the present attempt to point it out should not be perfectly satisfactory to him, I trust that he will refer to the subject, and that he will himself do morphologists the service of making it clear. For myself I have no hesitation in saying that, while fig. 1 is correct, figs. 2 and 3 are fundamentally wrong; and that Salensky's language requires correction wherever (*e.g.* p. 32) it implies that the long axes of the stigmata of the Ascidiozooid are parallel to the long axis of the endostyle, either in adult or embryo.

PROPOSED HANDBOOK to the BRITISH MARINE FAUNA.*

By W. A. Herdman, D.Sc., F.R.S.

[Read 11th December, 1892.]

The admirable monographs issued under the auspices of the Ray Society, and in Van Voorst's series, by such well-known authorities as Forbes and Hanley, Alder and Hancock, M'Intosh, Allman, Hincks, Brady, Norman, and others, are amongst the most creditable and useful productions of British Zoology, and all naturalists must devoutly trust that there are still others of a like classical nature to follow, and that, for example, Prof. M'Intosh will soon be able to complete his long-expected work on the British Polychæta.

But many Marine Zoologists feel that, quite apart from such exhaustive and expensive monographs, and only aspiring to occupy a very much humbler position, there is pressing need of a "pocket" or seaside "Invertebrate Fauna," which could be used in much the same way as the botanists' "Field Flora." It has been suggested to me more than once during the last few years that I would be doing useful work in compiling such a book; and as no one else seems ready or willing to do so, I feel inclined to make the attempt. Some material has already been accumulated for the purpose, but before going further I wish to lay my views before my fellow zoologists, in the hope that they will be kind enough to criticize the scheme and give me the benefit of their advice.

The only existing work of the kind is Gosse's well-

* This proposal was first brought before the Liverpool Biological Society, at the meeting held on November 11th, 1892.

known, and, so far as it goes, very excellent little "Manual of Marine Zoology," but that book does not really meet the present want, as not only is the date of publication 1855-6, since when the number of genera and species has probably been something like doubled, but also Gosse merely gives the names of the species, while the book I think of would, in order to be of any real use, require to aim at giving a brief but sufficient diagnosis and figure of every British* species. Fleming's "British Animals," published in 1828, probably represented well at that date the kind of book we want now; but Fleming gave no illustrations—and wrote sixty-five years ago.

Probably the most convenient form of publication would be some four to six small volumes, each dealing with one or two of the large groups. This would allow of the groups being published as they were ready, not necessarily in zoological order, and would also be convenient for the use of those interested in one set of animals.

There would be definitions—perhaps with occasional analytical tables or keys—of orders, families, &c., down to and including genera. Under each genus would be given all sufficiently defined species with a brief description of each, either in tabular form or in series, as seems most suitable in each case, and with an indication of size, range, and habitat. Many species might be described very briefly in terms of preceding species, the differences merely being pointed out. By simplicity of language, avoidance of unnecessary repetition, and use of contractions it might be hoped that each species could be confined on an average to a couple of lines.

Illustrations would be either in the form of numerous small outline figures on thin paper plates inserted as near

* I would probably adopt as "British" the area defined by Canon Norman's British Association Committee in 1887.

as possible to the pages where the descriptions occur, or as small groups of cuts (as in "Gosse") in the text. There would be a figure of the whole animal in each important genus, or small family, and the figures of the species would represent the diagnostic points only, *e.g.* in the zoophytes there would be a figure in the genus *Plumularia* of an entire colony, or shoot, while the species *pinnata*, *setacea*, *catharina*, &c., would be represented each by a small figure showing the pinnæ, calycles, or nematophores as the case required.

I shall now give a few examples, taken from different groups, of the method in which the genera and species might be treated, in order that specialists may have the opportunity of judging and criticizing.

I. From Cœlenterata:—Genus ANTENNULARIA, Lamk.

Stems simple or branched; pinnæ verticillate; nematophores along the stem; gonothecæ axillary, unilateral.

A. antennina, L., stems clustered, usually simple; hydrothecæ separated by 2 joints. 6 to 9 in. high. Gen. distr. deep w.

A. ramosa, Lamk., stems single, usually branched; hydrothecæ separated by 1 joint only. 6 to 9 in. high. Gen. distr. deep w.

II. From Crustacea:—Family MAIIDÆ.

HYAS, Leach. Carapace tuberculous, no spines; branches of rostrum not divaricated; second joint of antenna dilated; no teeth beneath last jt. of walking legs.

H. araneus, L., carapace not contracted behind postorbital process. 3 in. Common, shallow.

H. coarctatus, Leach, carapace contracted behind postorbital process. 1 in. Gen. distr., shallow.

PISA, Leach. Carapace may be tuberculous, with strong

postero-lateral spine; branches of rostrum divaricated at extremity; second joint of antenna slender; last jt. of walking legs toothed beneath.

P. tetraodon, Leach, carapace with small tubercles; antero-lateral margin with 4 spines. 2 in. Rare, S.

P. gibbsii, Leach, carapace with large rounded elevations, but no tubercles, no spines on antero-lateral margin. Rare, deep w., S. coast.

MAIA, Lamk. Carapace covered with numerous sharp spines; branches of rostrum strongly divaricated; no teeth beneath terminal joint of walking legs.

M. squinado, Latr. 10 in. long. S. and S.W. coasts.

III. From Tunicata :—Family MOLGULIDÆ.

EUGYRA, A. & H. Branchial sac with no folds.

E. glutinans, Möll., circular area on side free from sand. $\frac{1}{2}$ in. Shallow w., gen. distr.

E. globosa, Hanc., entirely covered with sand. $\frac{1}{2}$ in.

PERA, Stimp. Bran. s. with 5 folds each side.

P. hancocki, Hrdn., matted fibres at posterior end. $\frac{1}{2}$ in. Irish Sea. 20 fms.

MOLGULA, Forb. Bran. s. with 6 or 7 folds each side.

M. inconspicua, A. & H., 6 folds, sandy, dors. lam. entire, no papillæ on stigmata. $\frac{1}{4}$ inch.

M. impura, Hel., 6 folds, sandy, small papillæ on edges of stigmata. 1 in. W. of Ireland, shallow.

M. simplex, A. & H., few hairs, little or no sand, 6 folds, anus fringed, dors. tub. horse-shoe, aperture to left, $\frac{1}{2}$–$\frac{3}{4}$ in.

M. tubifera, Orst., 6 folds, anus fringed, dors. tub. horse-shoe, dors. lam. toothed, sandy. 1 in. E. coast.

M. ampulloides, v. Ben., 6 folds, anus fringed, dors. tub. horse-shoe, 3 bars on fold, dors. lam. entire. 1 in. E. coast, shallow.

M. socialis, Ald., 6 folds, anus fringed, dors. tub. horse-shoe, 4 bars on fold, dors. lam. entire, sandy, gregarious. $\frac{1}{2}$ in., shallow w. S. coast.

M. holtiana, Hrdn., 6 folds, dors. tub. serpentif., hairs but little sand on test. $\frac{3}{4}$ in. W. of Ireland, 10 fms.

M. occulta, Kupf., 7 folds, dors. tub. horse-shoe, dors. lam. toothed, whole body sandy. 1 in. Shallow w. S. and W. coasts.

M. oculata, Forb., 7 folds, siphonal region alone free from sand, and retractile between folds of test. 1 in. Gen. distr. Shallow w.

M. cœpiformis, Hrdn., 7 folds, globular, not attached, no sand. $\frac{3}{4}$ in. S. coast, shallow w.

M. citrina, A. & H., 7 folds, attached by left side, no sand. $\frac{1}{4}$–$\frac{1}{2}$ in. under st., litt. E. and W. coasts.

CTENICELLA, L-D., as MOLGULA, but branchial and atrial lobes laciniated.

C. complanata, A. & H., 6 folds on left, 7 on right, depressed, attached, sandy, $\frac{1}{4}$ in.

In conclusion, I need scarcely say that I shall be very grateful for suggestions, and, if the work is carried on, for any information from specialists about less known species, and the discrimination of allied forms, and for specimens, and also for references to any descriptions which might be likely to escape my notice.

[WORK FROM THE PORT ERIN BIOLOGICAL STATION.]

NOTE on LUCERNARIANS occurring in the neighbourhood of PORT ERIN, ISLE OF MAN.

By W. I. Beaumont,
EMMANUEL COLLEGE, CAMBRIDGE.

[Read May 12th, 1893.]

Three species of this interesting group have been found in the neighbourhood of Port Erin; of these, one—*Depastrum cyathiforme*—is fairly abundant, though apparently local in its distribution, and the examination of a number of specimens has enabled me to set at rest the divergent views which have been held with regard to it. The other two species have so far been found very sparingly: one is a well known and widely distributed form, the other will, I believe, prove to be a new species. The specimens were collected and examined while I was working at the L.M.B.C. Biological Station at Port Erin in the summer of 1892 and again in the spring of 1893.

Clark, in his Prodromus, (12)* divides the family Lucernaridæ (most of the members of which were originally described under the generic name of *Lucernaria*) into two sub-families:—

1. Cleistocarpidæ, characterised by the development of the gonads in "genital claustra" (mesogonial pouches and gastrogenital pouches of other authors) which are diverticula of the central enteric space or stomach. To this group belong *Depastrum*, *Craterolophus*, *Halicyathus*.

2. Eleutherocarpidæ, in which mesogonial pouches or claustra are absent, the gonads being formed in the subumbral or axial wall of the 4 perradial gastral pouches

* The numbers in brackets refer to the List of Authorities at the end.

(the 4 cameræ of Clark). *Lucernaria* (as now restricted) and *Haliclystus* belong to this sub-family.

Between the publication of Clark's Prodromus (12) in 1863, and of Haeckel's "System der Medusen," 1879 (15) there had been found a number of species closely allied to the already known Lucernarians but having the stalk in a rudimentary condition, and thus forming a link with the ordinary free-swimming medusæ. For these Haeckel founded the family Tesseridæ, which with the family Lucernaridæ constitute his order Stauromedusæ, the latter family coinciding with Clark's Lucernaridæ, except that *Depastrum* is removed from it and placed among the Tesseridæ on account of its supposed relationship to *Depastrella*, a species of the Tesseridæ discovered by himself in the Canary Islands, which unlike the rest of the sub-family has a well developed stalk for attachment. Now although *Depastrum* has some points in common with *Depastrella*, yet in internal structure it differs very materially, and I prefer to follow Clark in retaining it among the Lucernaridæ.

Sub-family—Cleistocarpidæ.

Depastrum cyathiforme, (Sars.)

This species was discovered last year by myself and Mr. Gamble on the S. side of Port Erin Bay. I found it again during the recent vacation in the same locality, and also on the limestone rocks at Poyllvaaish. It is fairly abundant in both localities, attached to the under surface of stones, being apparently most plentiful above the Laminarian zone, though occurring in that zone also more sparingly, but according to my experience of larger size. It is very firmly attached, and I doubt whether it ever moves from the spot where it first attaches itself; I have never seen a detached specimen re-attach itself, in-

deed I do not think it is capable of doing so. In this respect it differs from most Lucernarians. This species has been the subject of no little confusion, into the discussion of which I must enter at some length.

It was first described and figured in 1846 as *Lucernaria cyathiformis*, by Michael Sars, in the "Fauna Littoralis Norvegiæ," (4). In 1858 Gosse in his "Synopsis of the British Actiniæ" (5) founded the genus *Depastrum*, based, I think, chiefly on specimens found by himself at Weymouth, which he regarded as identical with the *Lucernaria cyathiformis* of Sars. In 1859 Allman who had also discovered (in the Orkney Islands), what he considered the *Lucernaria cyathiformis* of Sars, in ignorance of Gosse's name, instituted a second one—*Carduella* (6), and in the following year gave a more detailed account of his species (7) with figures. Similarly a third generic name was founded by Milne Edwards (10) viz., *Calicinaria*. Gosse then pointed out (8) the claims of his name *Depastrum* to priority, he also gave further details with figures of the Weymouth specimens which he now elevated to specific rank as *Depastrum stellifrons* as it appeared to differ in certain points from Allman's species which retained the name *Depastrum cyathiforme* since he (Gosse) regarded it as identical with the *Lucernaria cyathiformis* of Sars. To this Allman replied (9) that the points of difference between *Depastrum* and *Carduella* were of generic not specific value merely, and that the name *Carduella cyathiformis* must stand for his own and the Norwegian form, which he also regarded as identical. Thus the matter rested until the publication of Clark's Prodromus in 1863 (12) wherein the matter was practically cleared up, Clark having had the advantage of being able to compare specimens of the Orkney form from Allman with specimens of various ages sent to him by Sars from Norway.

Now the points insisted on as distinguishing *Depastrum* from *Carduella* were these:—that while in both the tentacles are arranged in 8 groups round the margin of the disc oral surface of bell or umbrella) yet in *Depastrum* the tentacles are very numerous, and are arranged in each group in *several rows or series,* one within another, and further that they spring *from the margin* of the *octagonal disc* or from *without* it, but that in *Carduella* there are only about 5 tentacles in each group arranged in a *single series* and arising completely *within* the margin of the *circular disc.* Further in *Carduella* there is a single tentacle (primary tentacle of Haeckel, corresponding to the marginal anchors of *Haliclystus*) in each interval between the groups of other tentacles; this does not seem to have been observed by Gosse in *Depastrum.* Clark pointed out that, according to the figures and description of Sars, confirmed and extended by his own examination of the specimens sent to him by the latter, the Norwegian species when adult has the tentacles arranged in several rows (3 or 4), but that the younger individuals have at first only one row and later two. Further he pointed out that Allman was in error in asserting that the Orkney form always had its tentacles in one row only, for some of those sent to him, being presumably older than those described by Allman, had more than one row. He accordingly concluded that *Carduella* as defined by Allman was merely the young form of the *Lucernaria cyathiformis* of Sars. With regard to this point, the examination of a large series of specimens at Port Erin has amply confirmed the conclusions of Clark. Now as to the *Depastrum* of Gosse, Clark inserts it provisionally as a distinct genus, but at the same time he gives some very good reasons for regarding it also as identical with *Lucernaria cyathiformis,* Sars. The difference in the number and arrange-

ment of tentacles having been disposed of as far as the groups of secondary tentacles were concerned (as detailed above), there only remained the octagonal disc and absence of primary tentacles in *Depastrum* to separate it from *Carduella*.

With regard to the first point, as Clark points out, there is in Sars' figures (and in Allman's also) an octagonal area, the corners of which correspond to the intervals between the tentacular groups and whose outline is marked out by a distinct line of brown pigment; the tentacles arise from immediately without this line, and there can be little doubt that this is the octagonal margin of the disc spoken of by Gosse, but the real margin of the disc is formed by the circular muscle situated outside the origin of the tentacles, some of which are usually curved over it when the animal is fully expanded, the primary tentacles being invariably so apparently. This circular muscle is in life a delicate translucent structure and may have escaped Gosse's notice. Then as to the absence of primary tentacles in *Depastrum*. These in *Carduella* are similar in form and structure to the secondary tentacles of the groups, unlike those of *Haliclystus auricula* which have been modified into the so-called marginal anchors and function as adhesive organs. They are in *Carduella* not very conspicuous, being usually somewhat smaller than the secondary tentacles and constantly (as I have remarked above) reverted over the circular marginal muscle and closely applied to its surface. It is accordingly not unlikely these too escaped Gosse's observation, especially if his specimens had been kept long, as the tentacles seem apt to slough away when the animal is removed from its natural conditions. In addition I may mention that *Depastrum*, and apparently other members of this group also, is subject to much variation, especially in

the number and arrangement of the tentacles; indeed of the many specimens examined at Port Erin very few had quite the typical arrangement. Sars also notices this and mentions one specimen with 7 pairs of gonads instead of the typical 4; the gonads seem more regular than the tentacles, but I have seen several individuals with 6 pairs, one of which had 13 groups of tentacles.

There can be, I think, little doubt that the Weymouth species is identical after all with *Carduella* and with the *Lucernaria cyathiformis* of Sars. And I may mention that a specimen recently found at Plymouth which has been kindly lent to me for comparison, differs in no way (externally) from the Port Erin form. That the latter is the *Lucernaria cyathiformis* there can hardly be a doubt, not only does it agree in external features with the figures of Sars and the description of Clark, but also as to its internal structure it is quite in accord with the account given by the latter (with one not very important exception).

This conclusion was at first accepted by Haeckel who inserts this species in his "System der Medusen" (15, p. 379) as *Depastrum cyathiforme*, Gosse, with *Lucernaria cyathiformis* and *Carduella* as synonyms; but in an appendix (15, p. 369) he departs from this view in consequence of having himself found on the Sutherland coast a form, agreeing with Allman's *Carduella* in having the tentacles in one row only, but which cannot be merely a young *Depastrum* since it is sexually mature, reproducing itself in that form with one row of tentacles. This, agreeing in its main structural features with the species *Depastrella carduella* discovered by himself in the Canary Islands (but at first called by him *Carduella depastrella*), Haeckel now names *Depastrella allmani*, giving *Carduella cyathiformis* Allman, as a synonym, and the Orkney Islands as one of its localities. Now whatever the *Depastrella allmani*

from the Sutherland coast may be, there is very strong evidence that it is not the same species as the Orkney *Carduella.* First, since Clark had been able to compare undoubted specimens of the latter with specimens of *Lucernaria cyathiformis* from Sars, his opinion as to their identity must carry great weight; and secondly, Clark has given an account of the structure of this species, based on the above named specimens, the accuracy of which Haeckel acknowledges; and this account shows that these specimens differ materially in their internal organisation (more especially in the presence of mesogonial pouches) from the structure which is found in the genus *Depastrella* according to the type species from the Canary Islands—*Depastrella carduella,* of which he gives figures. He gives no figures of *Depastrella allmani* but describes it as having practically the same internal structure as *Depastrella carduella,* consequently if Haeckel's description of the Sutherland species be correct, it is obvious that its internal anatomy differs considerably from that of *Carduella,* however similar they may be in external features, and we may safely conclude that *Carduella cyathiformis, Depastrum cyathiformis* and *Lucernaria cyathiformis* are one and the same species.

Sub-family—ELEUTHEROCARPIDÆ.

Haliclystus auricula, (Rathke).

A small *Haliclystus* was found near Port St. Mary by M. Chopin, in 1891, on a lobster pot I believe, and is now in the Zoological Museum at University College, Liverpool. I have seen the specimen and, as far as I can judge, it is *H. auricula,* but it may possibly be *H. octoradiata* (Lamarck, 3). The shape and size of the marginal anchors seem to be those typical of *H. auricula;* the characters of the gonads I have not been able to make out satisfactorily. With regard to these two species we again meet with

confusion, but since I have seen specimens from Plymouth and Jersey which have all the distinguishing characters of the *Haliclystus auricula* described by Clark in his Prodromus (12) and again with great detail in a fully illustrated monograph in the Smithsonian Contributions, 1878, (14) I prefer to follow Clark in identifying his species with the European *Lucernaria auricula*, Rathke (2). Haeckel on the other hand considers it probable that *Haliclystus auricula*, Clark, is confined to the American side of the Atlantic, and identifies *L. auricula*, Rathke, with *L. octoradiata*, Lamk., which is described as a second European species by Clark. Rathke's figures as far as they go support Clark's view.

It may be noted further that *Lucernaria auricula*, Rathke, was confused by a number of the earlier writers with *L. auricula*, Fabricius (1), one of the Cleistocarpidæ [*Manania auricula* (Fab.) Clark, *Halicyathus lagena* (Müller) Haeckel].

Haliclystus, sp.

The third species of Lucernarian found at Port Erin differs materially from any species previously described as far as I know. The members of this family seem particularly liable to abnormalities affecting more especially the number and arrangement of the tentacles, as noticed under *Depastrum*, and I am loth to establish a new species on the scanty material at present available. After some consideration, I refer this species provisionally to the genus *Haliclystus*, for though it presents considerable divergence from the 3 species of that genus which have been already described, yet its structure, so far as I have been able to make it out, is in accordance with the generic definition both of Clark and Haeckel except as regards one point which is not I think of very great importance.

Three examples of this form were found last year;

they were attached to the undersides of stones on the S. side of Port Erin Bay, where *Depastrum* also occurs. During the recent vacation I made a most careful search in the same locality but failed to find a single specimen. On the first occasion in my ignorance of the "points" of a Lucernarian, I did not observe in the living animal the presence of primary tentacles, but in one of the three specimens these are now plainly enough to be seen, but in the others which are smaller and were not preserved in an expanded condition I have been unable to ascertain whether these important organs are present or not. Now in *Haliclystus auricula* additional tufts of tentacles seem not uncommon, and accordingly, until I have seen more specimens I hesitate to conclude that what certainly appear to be genuine primary tentacles (retaining the original tentacular structure instead of being modified into marginal anchors as in *H. auricula*) are really normal structures.

If on the other hand these primary tentacles are merely individual abnormalities, and if I am right in my interpretation of its internal structure, then this species must be relegated to the genus *Lucernaria* (as at present restricted). In the approximation of its arms in pairs it approaches *L. quadricornis,* Müller, but its complicated gonads differ from those of that species. I at first took the Port Erin specimens to be small and somewhat abnormally shaped *L. quadricornis,* before I had discovered the primary tentacles; they are referred to under this name in the L.M.B.C. Annual Report, 1892 (p. 33). I now append a description of the species :—

HALICLYSTUS sp. (? n. sp.)

Umbrella somewhat conical, passing gradually into the stalk without any marked distinction. Sub-umbrella cavity very shallow.

Stalk more or less round in transverse section with 4 longitudinal grooves marking the position of the 4 interradial muscles, decreasing in diameter from its junction with the umbrella and then expanding again at its aboral end into the disc for attachment. 1-chambered. (The other species of *Haliclystus* have the stalk 4 chambered.)

Arms 8, but so closely united in pairs, that there appear to be only 4, separated by 4 very wide perradial "bays," the interradial intervals being practically obliterated.

Primary tentacles 8. The 4 perradial ones are smaller than the secondary tentacles but similar in form, they stand out horizontally from just within the margin of the umbrella. The 4 interradial ones spring from the point of junction of the paired arms, between the tufts of secondary tentacles and resemble the latter.

Secondary tentacles are grouped in tufts on the ends of the arms, about 7 on each, but in consequence of the fusion of the arms in pairs, there appear to be only 4 tufts of tentacles, each of about 15; really each consists of the tufts belonging to a pair of arms together with what I regard as the intervening interradial primary tentacle. The tentacles are somewhat club shaped, the head not being distinct from the stalk.

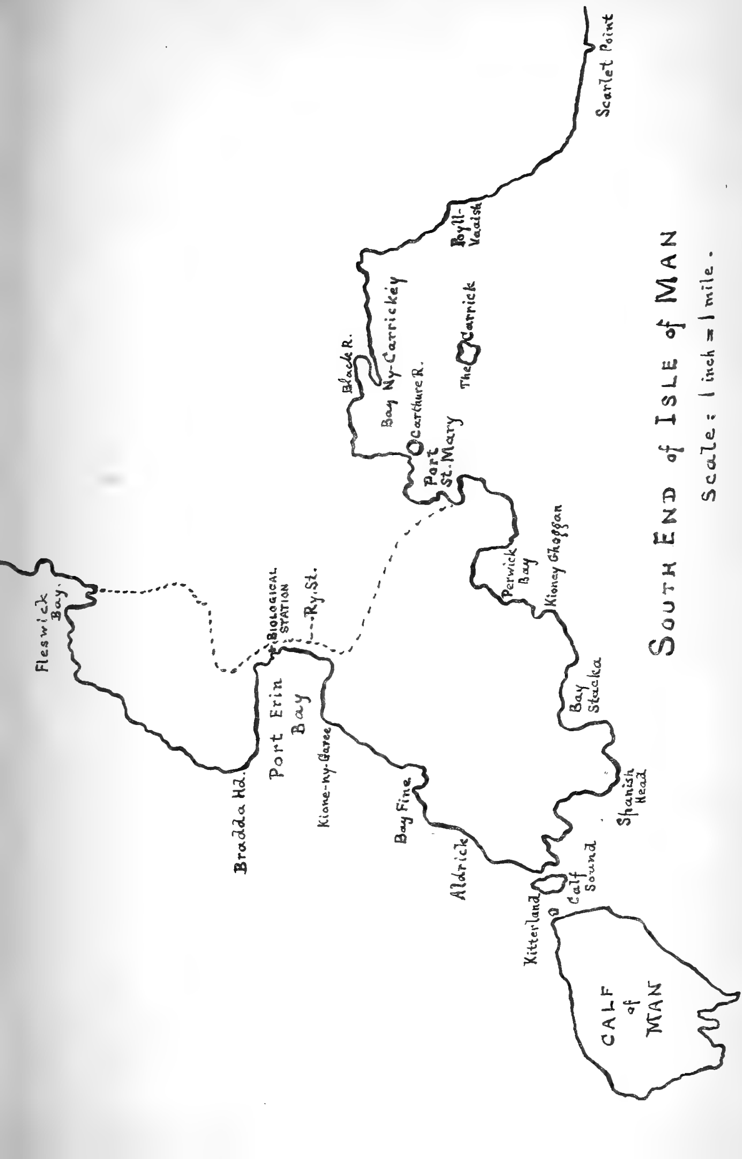
Gonads. These consist of numerous saccules forming 4 adradial bands in the endoderm lining the subumbral wall of the 4 perradial gastral pouches. These walls are very much folded, and in transverse sections the whole gastral cavity appears almost packed with the genital saccules.

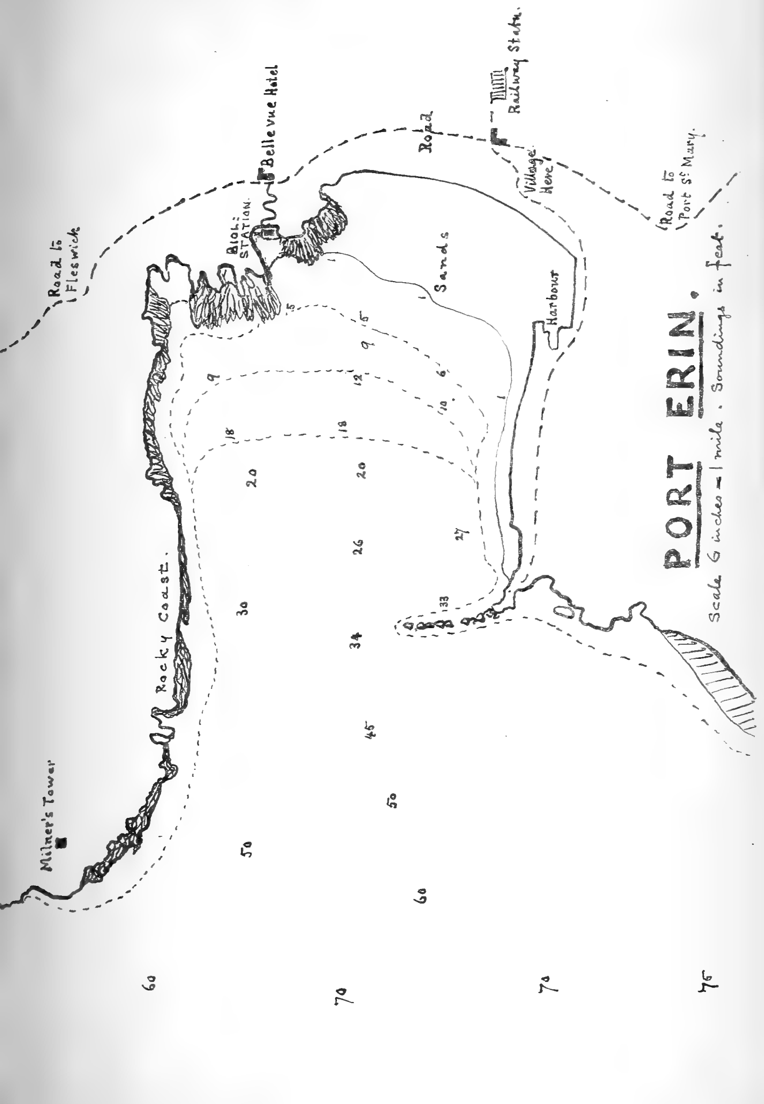
Size. Height including stalk—about 7 mm. Width of umbrella—about 3 mm.

Colour. A rather dull pale yellow.

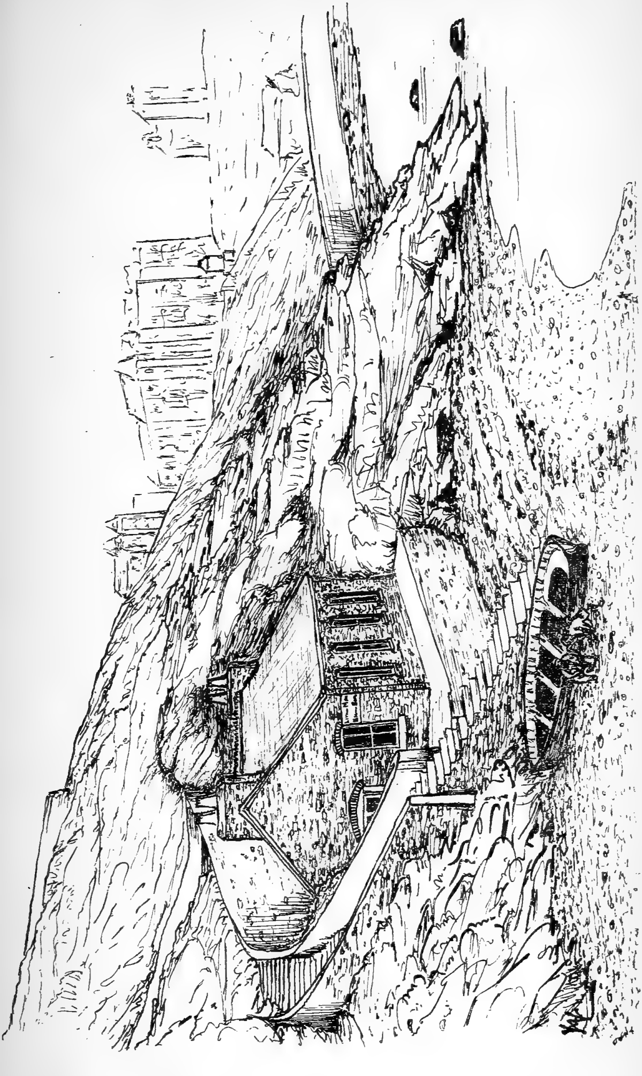
LIST OF AUTHORITIES REFERRED TO:—

1.—1780. O. Fabricius—Fauna Groenlandica, p. 341.
2.—1806. Rathke—Müller's Zool. Danica, vol. IV.
3.—1816. Lamarck—Hist. Nat. anim. II.
4.—1846. M. Sars—Fauna Littoral. Norweg. Fasc. I.
5.—1858. Gosse—Ann. & Mag. Nat. Hist. vol. I, p. 419.
6.—1859. Allman—Report Brit. Assoc., Aberdeen.
7.—1860. ,, —Trans. Micros. Soc. VIII, p. 125 & Pl.
8.— ,, Gosse—Ann. & Mag. Nat. Hist. V, p. 481.
9.— ,, Allman— do. do. VI, p. 41.
10.— ,, Milne Edwards—Hist. des Corall. III, p. 459.
11.—1862. Keferstein—Zeitschr. für wiss. Zool. XII, p. 24.
12.—1863. Clark.—Prod.Lucernar.Jour.Boston Soc. N.H.
13.—1877. Taschenberg—Halle Zeits.Naturw,Bd.49,p.94.
14.—1878. Clark—Lucernar.Monog.Smithsonian Contrib.
15.—1879. Haeckel—System der Medusen.

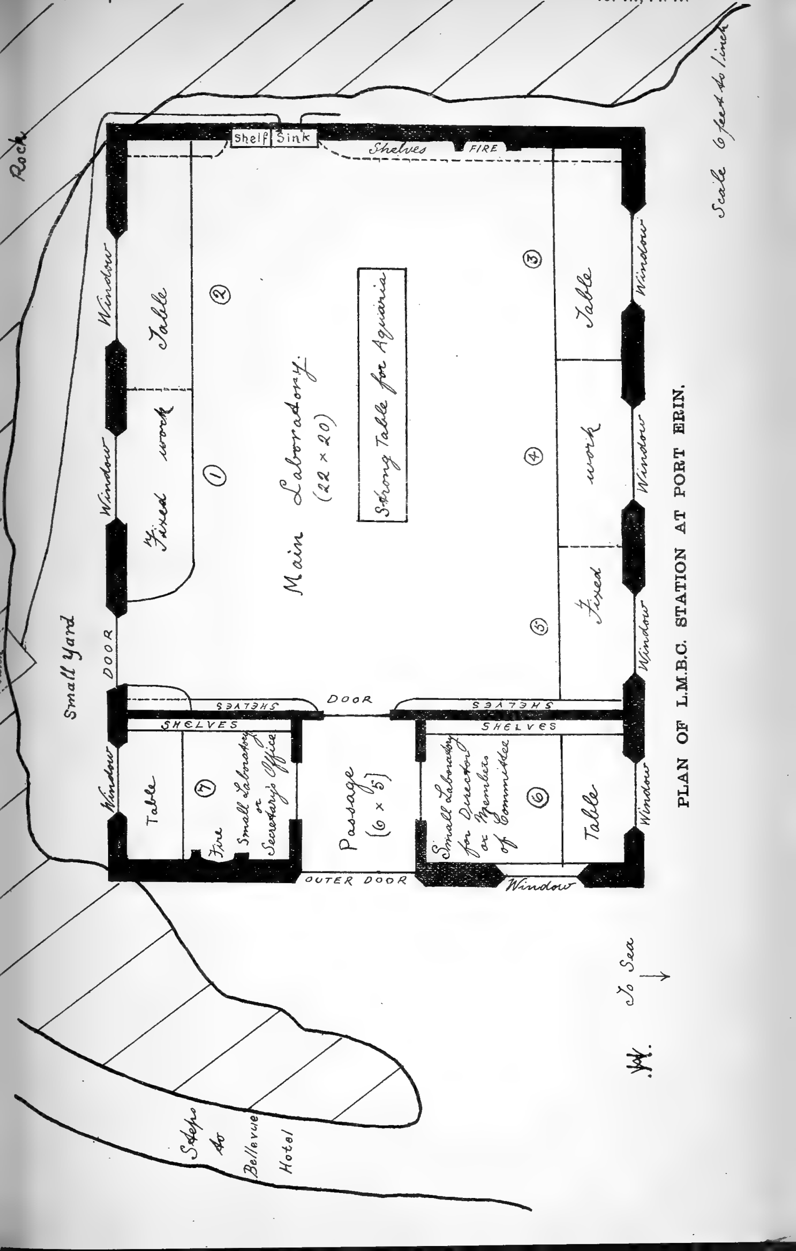

South End of Isle of Man
Scale: 1 inch = 1 mile.
Scarlet Point
Poyll-Vaaish
Bay Ny-Carrickey
Black R.
The Carrick
Carthure R.
Port St. Mary
Kioney Ghoggan
Perwick Bay
Bay Stacka
Spanish Head
Calf Sound
Kitterland
CALF of MAN
Aldrick
Bay Fine
Kione-ny-Garee
Port Erin Bay
Bradda Hd.
Fleswick Bay
BIOLOGICAL STATION
Ry. St.



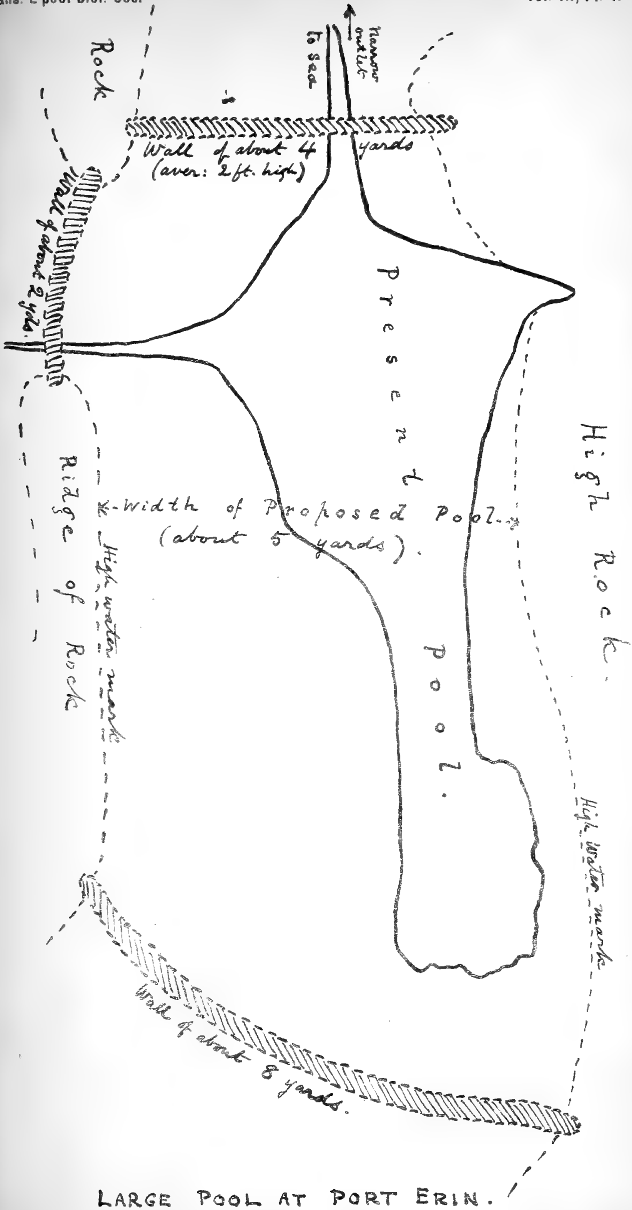
Road to Fleswick
Biol: Station
Bellevue Hotel
Road
Railway Statn.
Village Here
Road to Port St Mary.
Sands
Harbour
Rocky Coast.
Milner's Tower
PORT ERIN.
Scale 6 inches = 1 mile. Soundings in feet.



LIVERPOOL MARINE BIOLOGICAL STATION AT PORT ERIN.



PLAN OF L.M.B.C. STATION AT PORT ERIN.



LARGE POOL AT PORT ERIN.

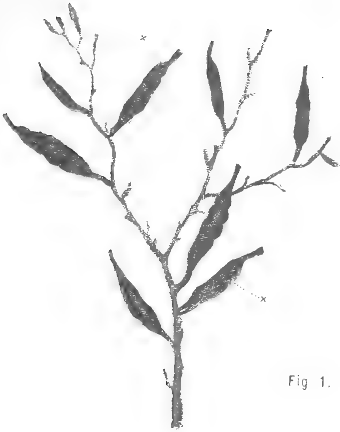


Fig 1.

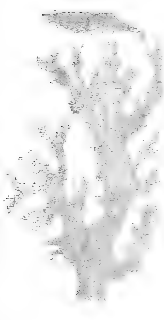
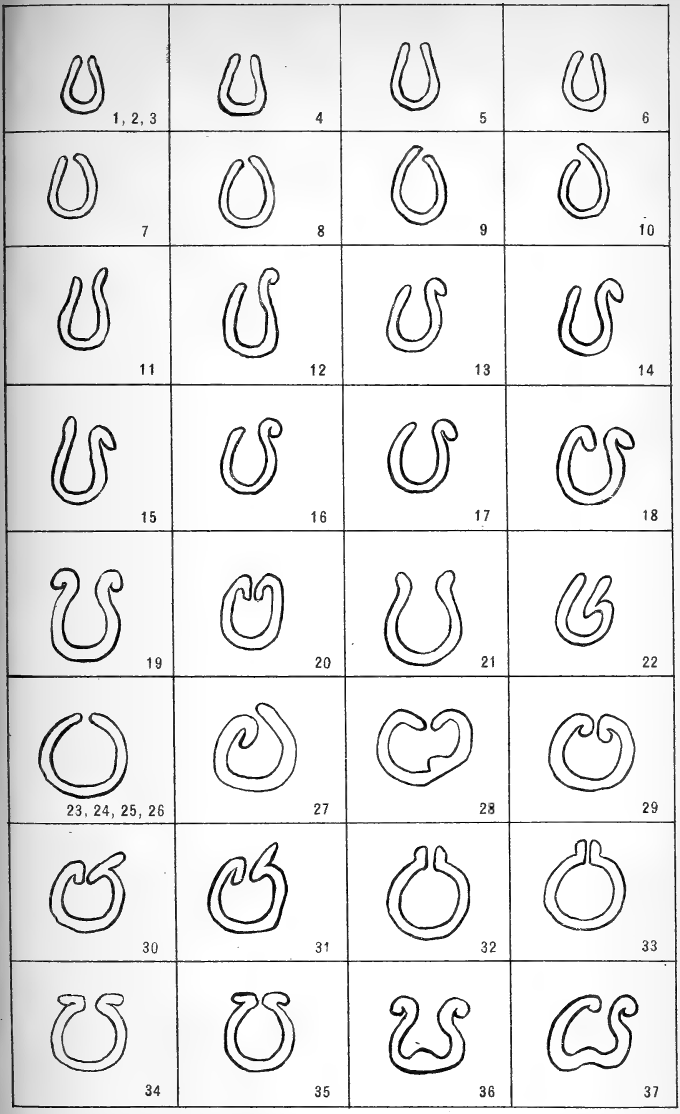


Fig. 2.

Fig. 3.

W A. H., pinx.

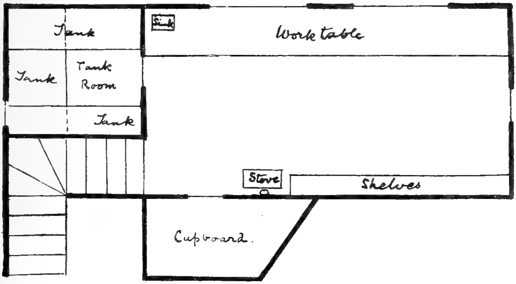
VIRBIUS VARIANS.



A. E. W., del.

DORSAL TUBERCLE OF ASCIDIA VIRGINEA.

Fig. 1.



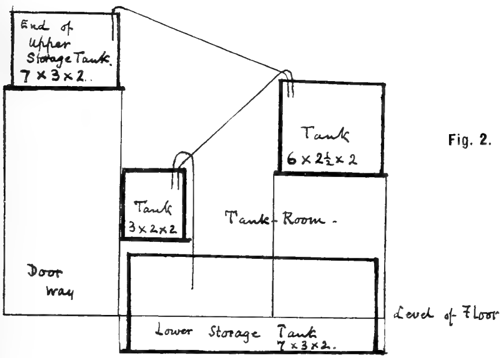


Fig. 2.

FISHERY LABORATORY.

Fig. 1.

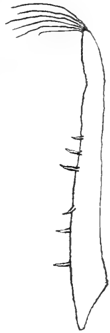


Fig. 3.

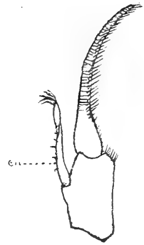


Fig. 2.

Fig. 6.

Fig. 5.

Fig. 4.

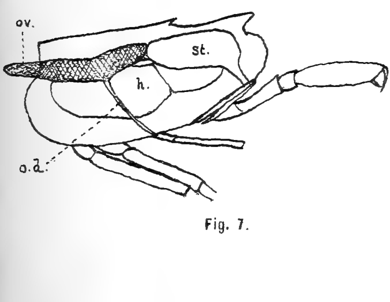


Fig. 7.

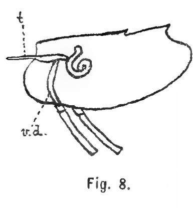
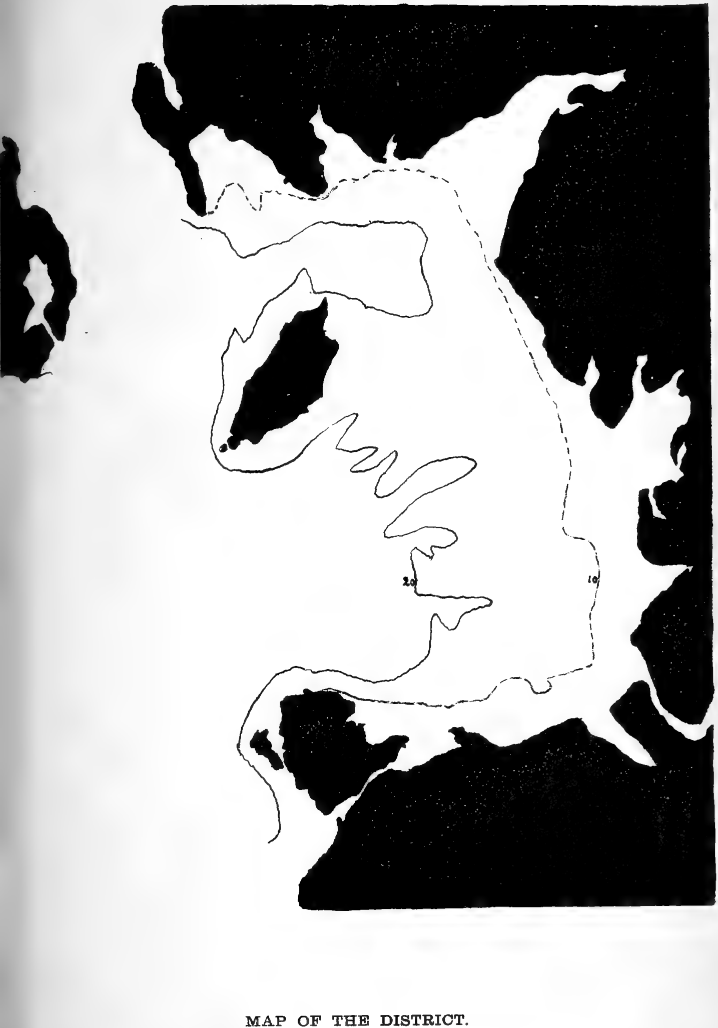


Fig. 8.

MALE and FEMALE SHRIMP.



MAP OF THE DISTRICT.

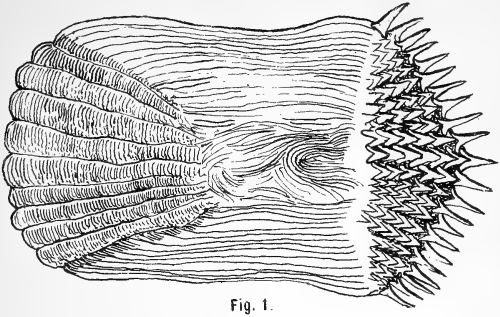


Fig. 1.

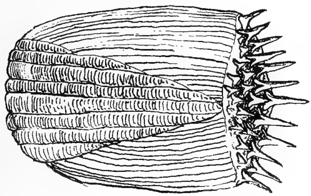


Fig. 2.

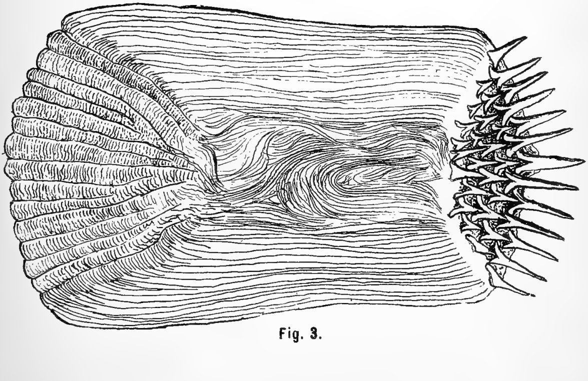
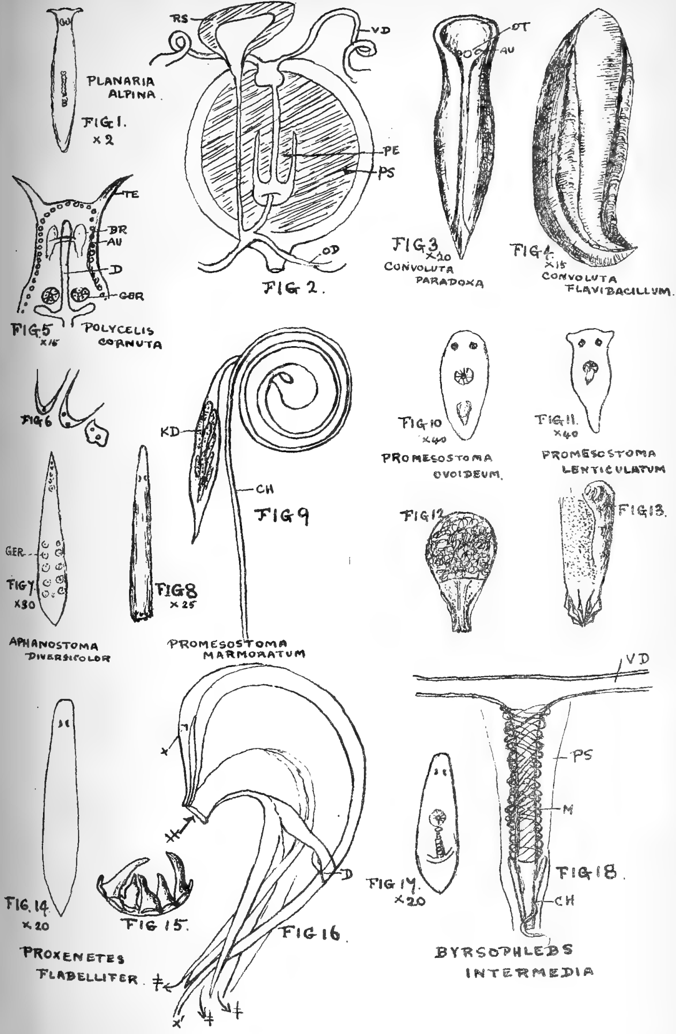


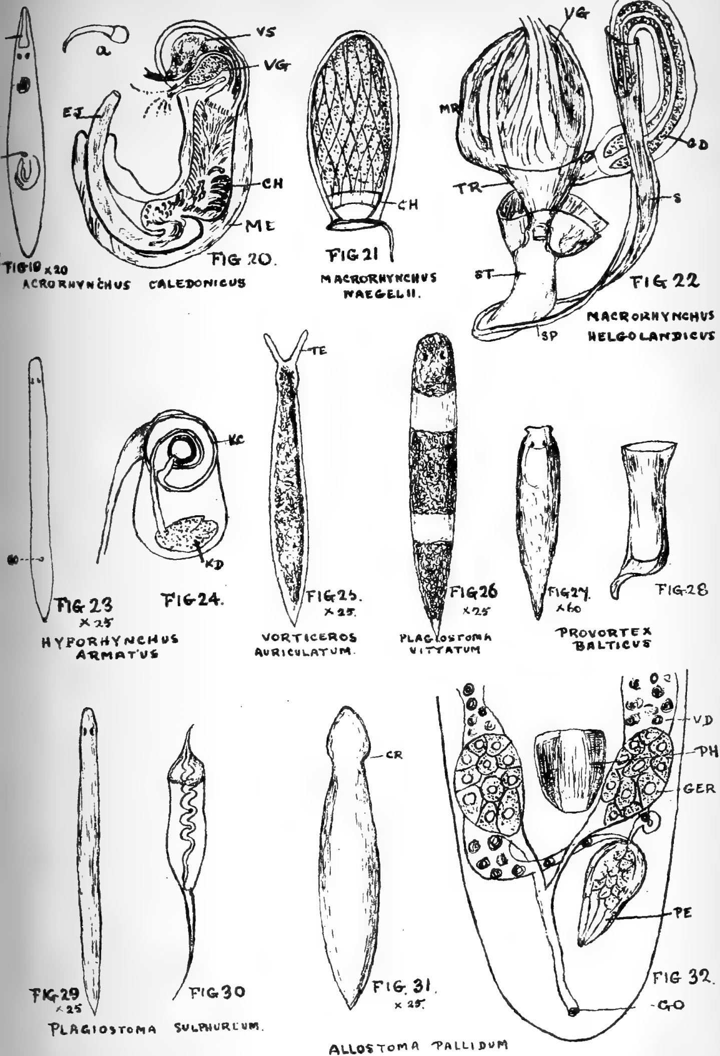
Fig. 3.

SCALES OF SOLE AND SOLENETTE.



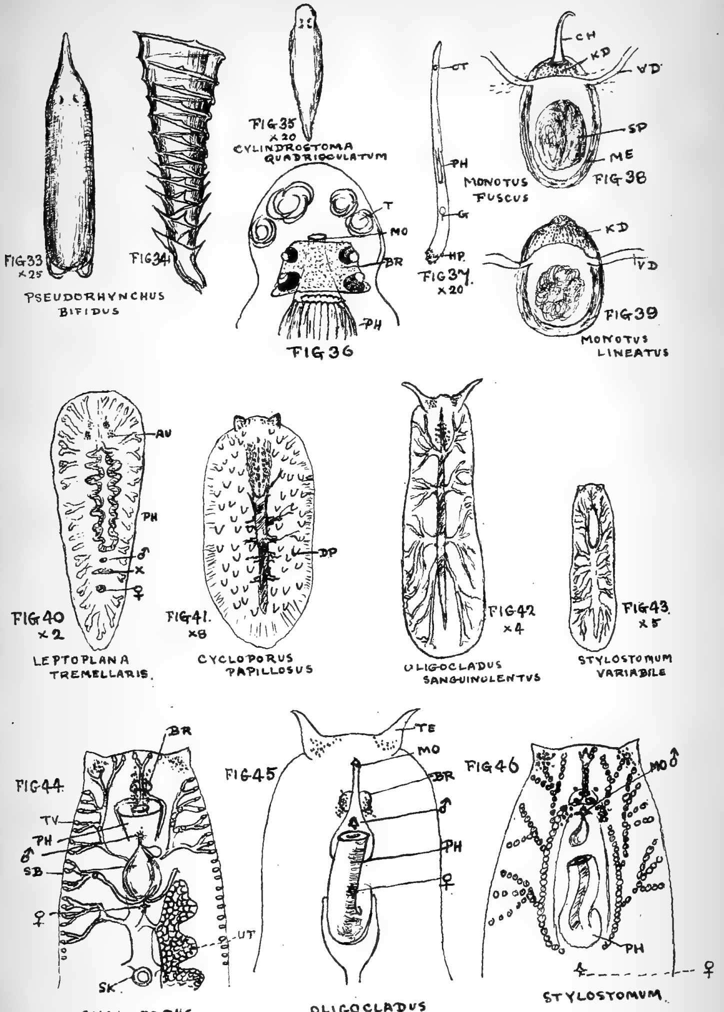
W. G., del.

L.M.B.C. TURBELLARIA.



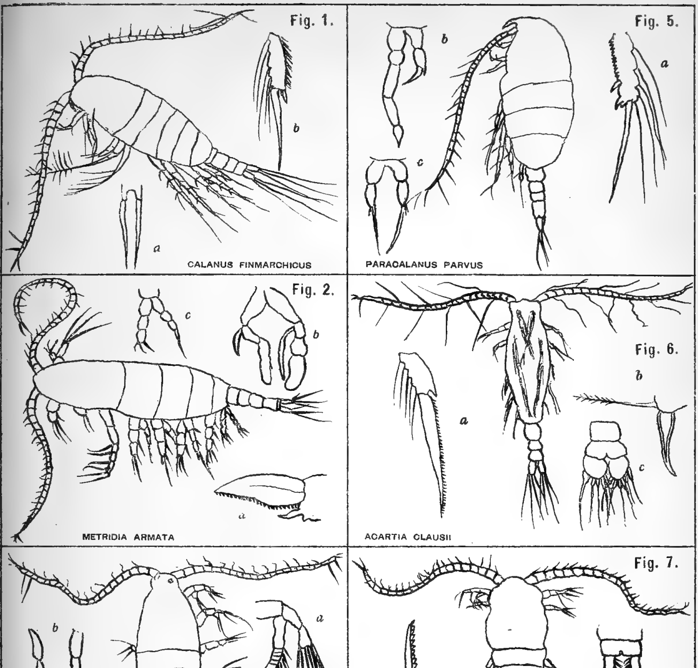
F. W. G., del.

L.M.B.C. TURBELLARIA.



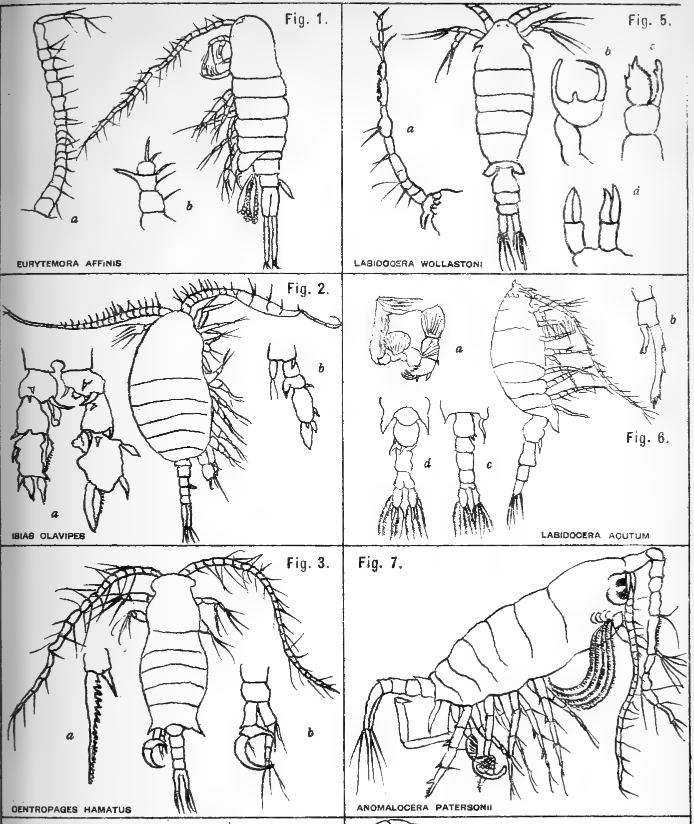
F. W. G., del.

L.M.B.C. TURBELLARIA.



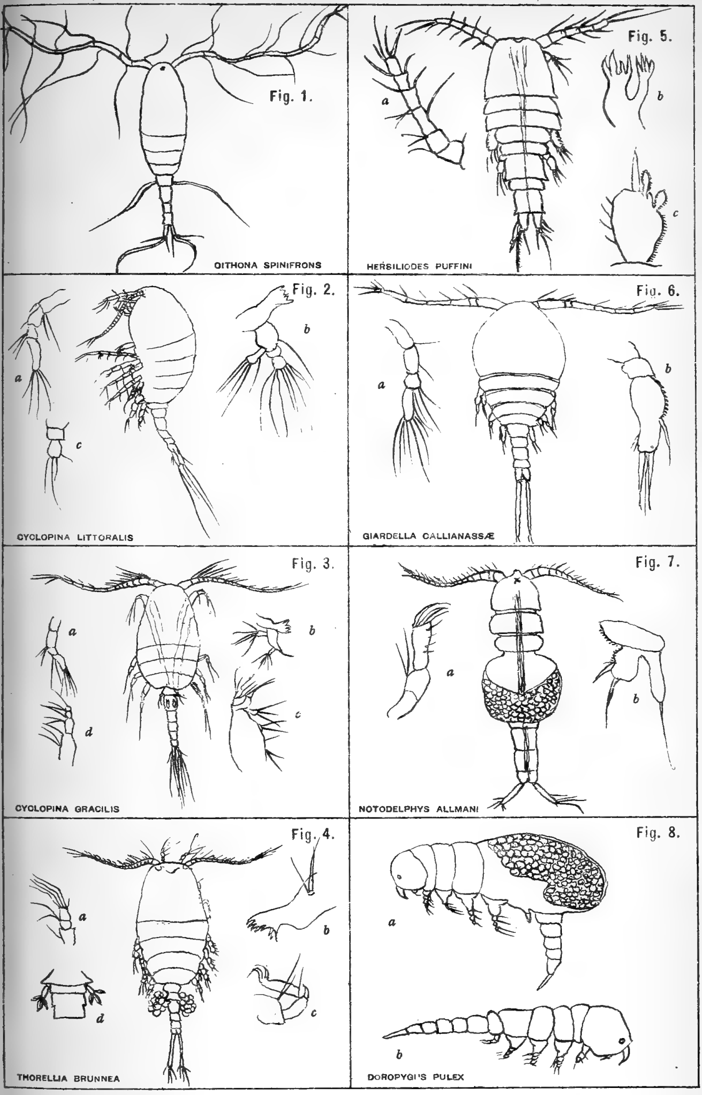
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



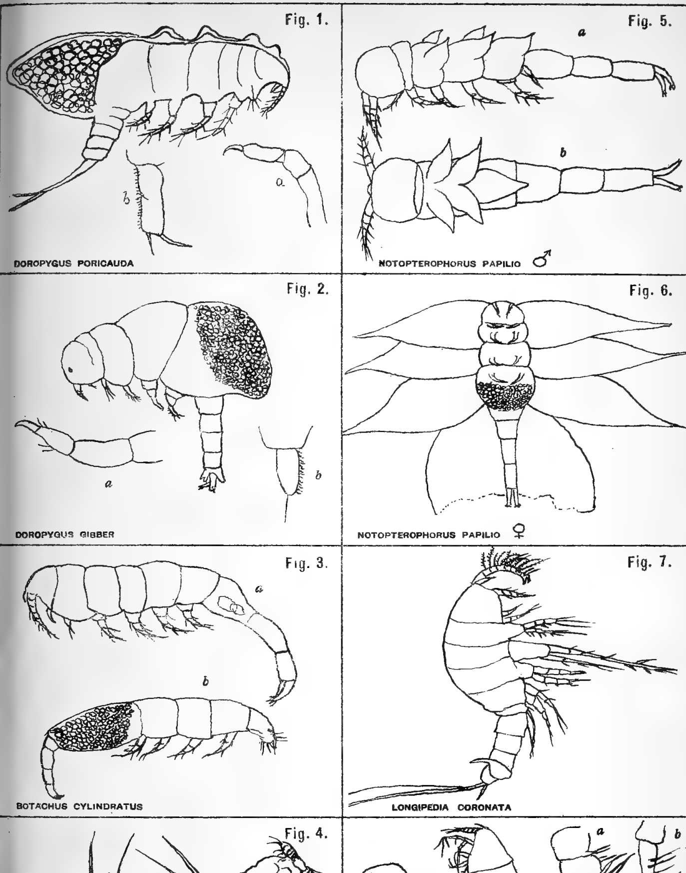
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



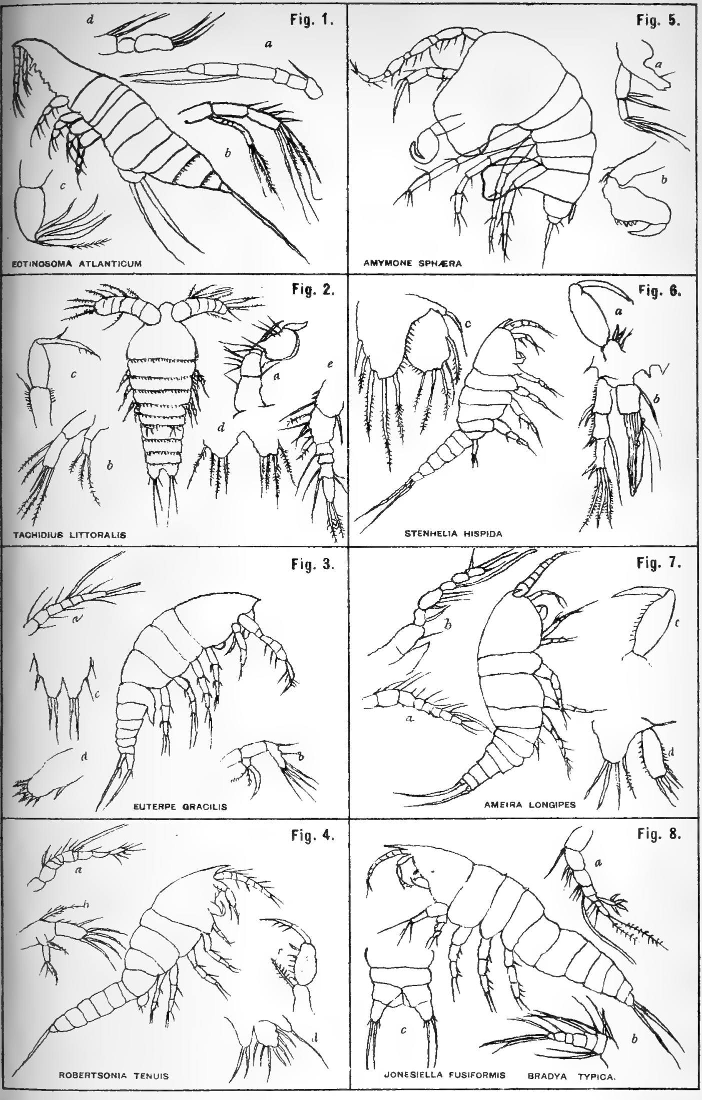
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



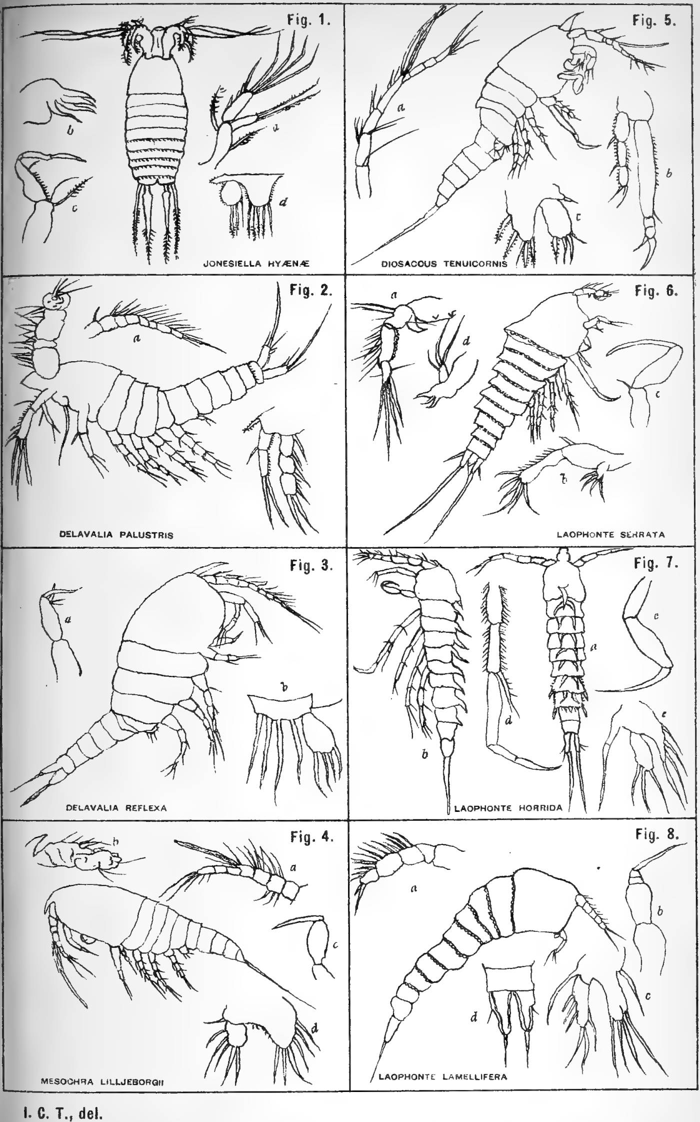
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



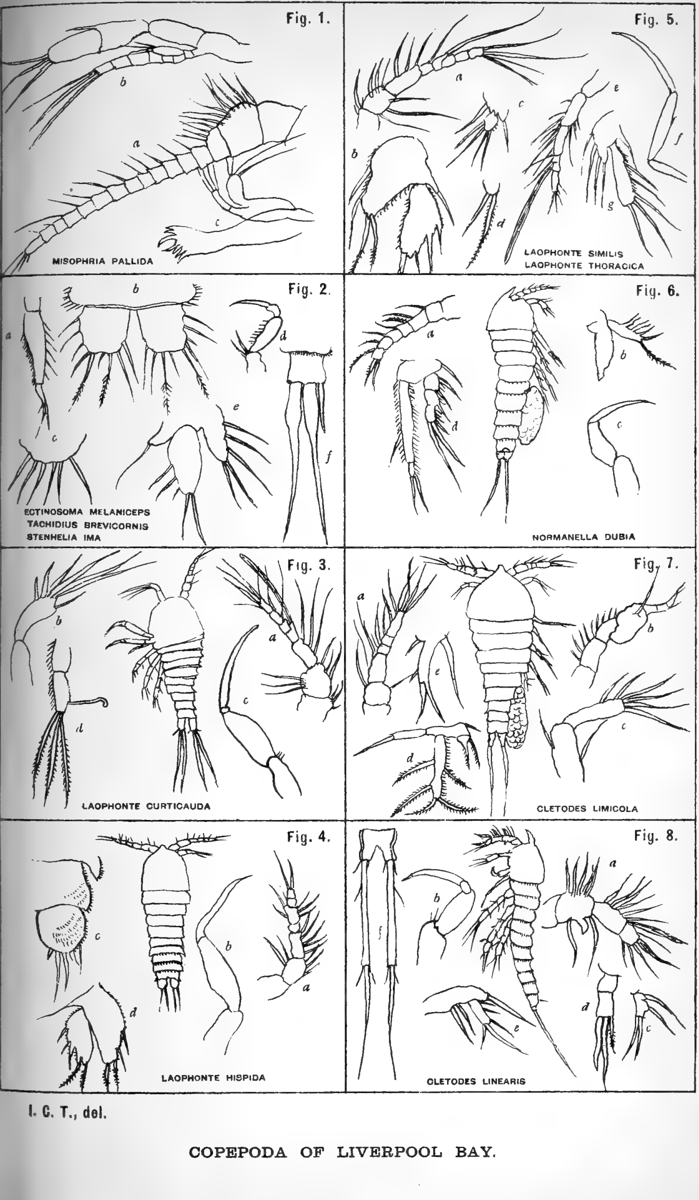
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



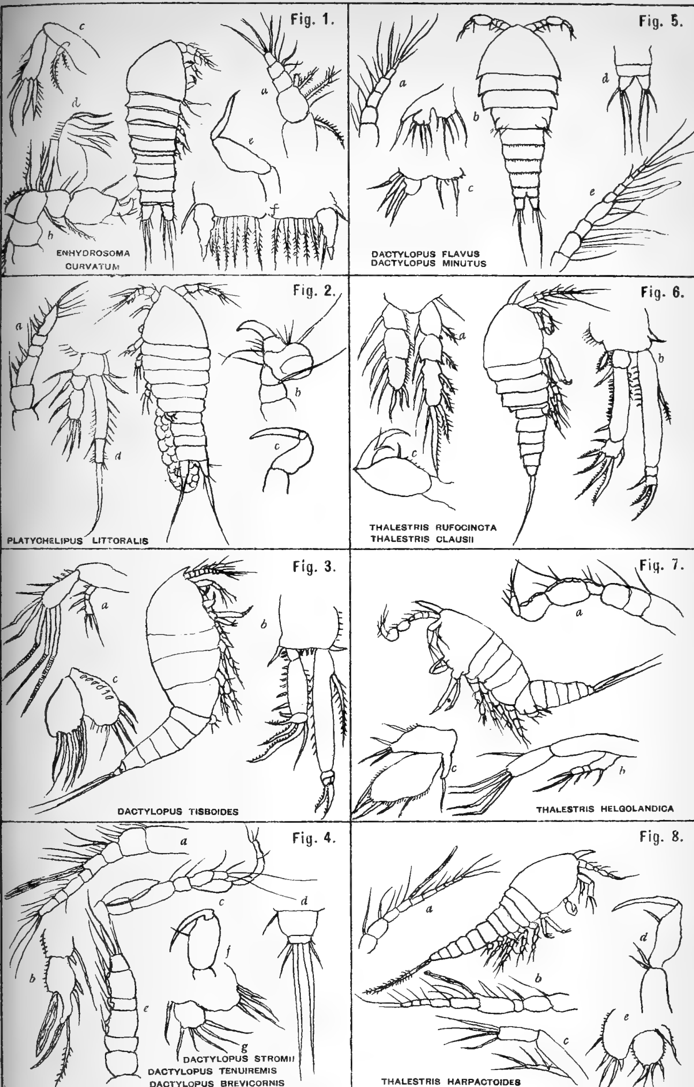
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



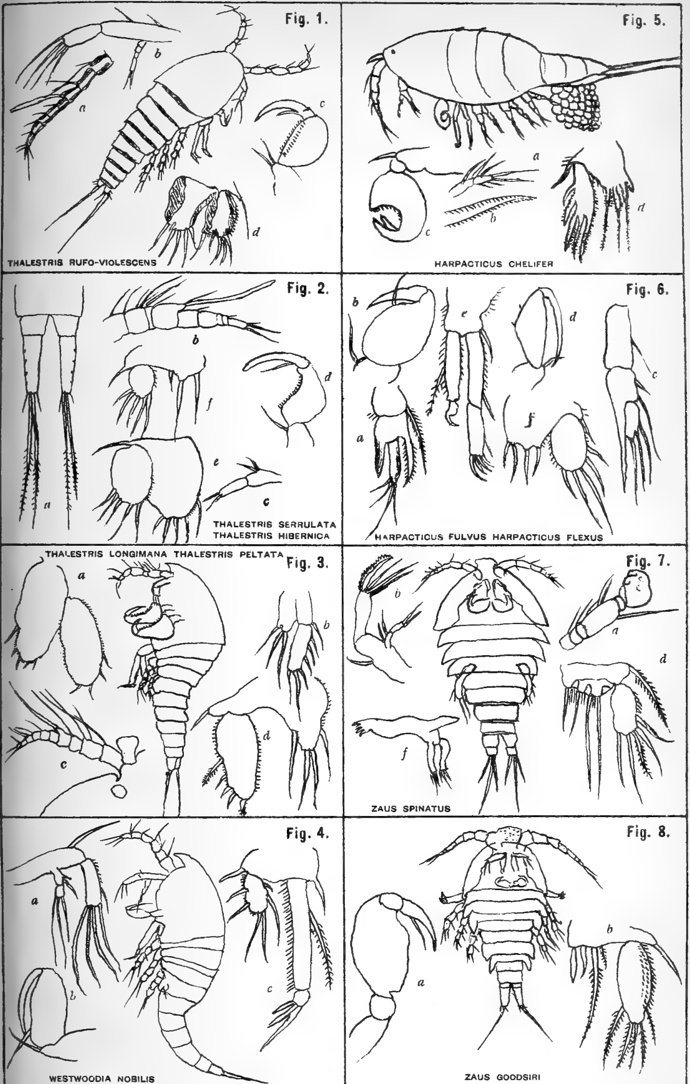
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



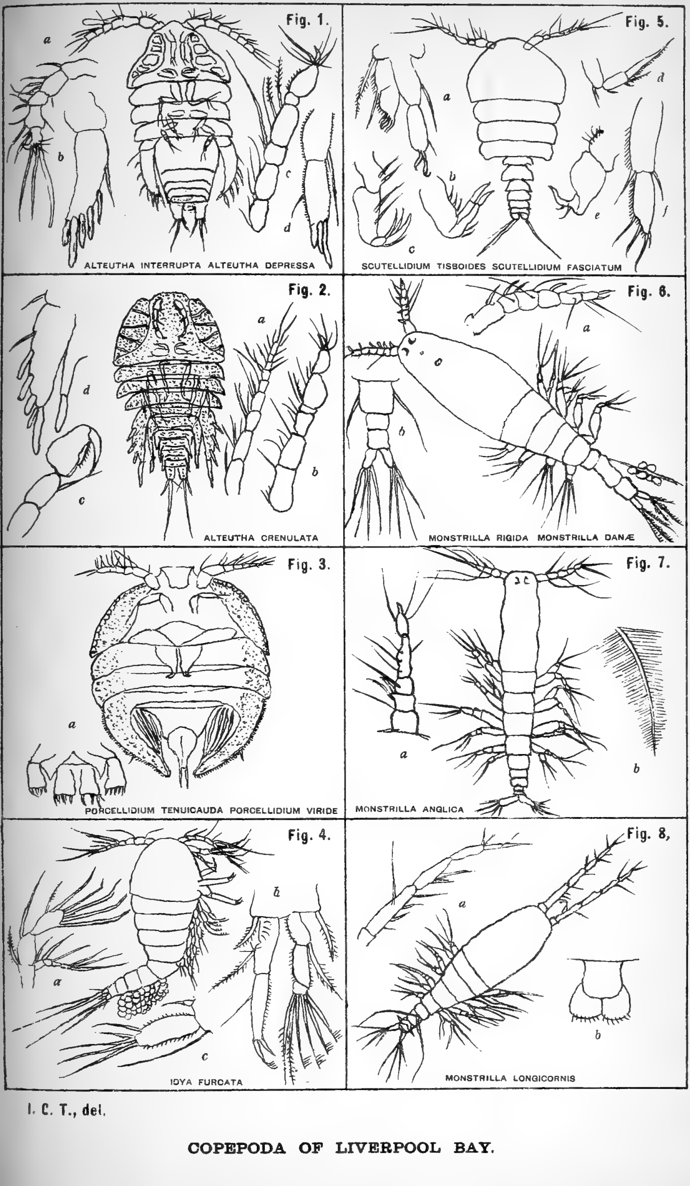
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



I. C. T., del.

COPEPODA OF LIVERPOOL BAY.

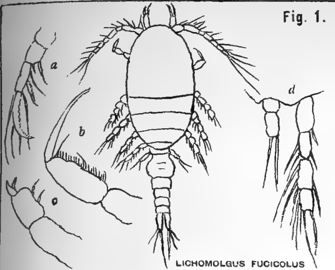


Fig. 1.
LICHOMOLGUS FUCICOLUS

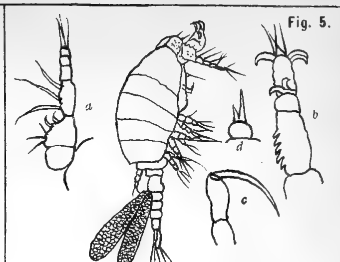


Fig. 5.
SABELLIPHILUS SARSII

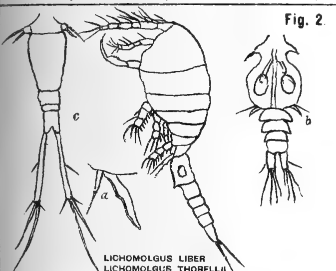


Fig. 2.
LICHOMOLGUS LIBER
LICHOMOLGUS THORELLII

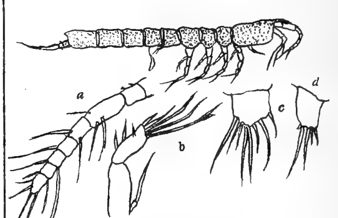


Fig. 6.
CYLINDROPSYLLUS LÆVIS

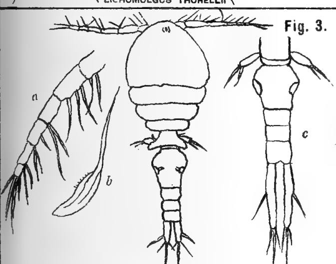


Fig. 3.
LICHOMOLGUS FURCILLATUS

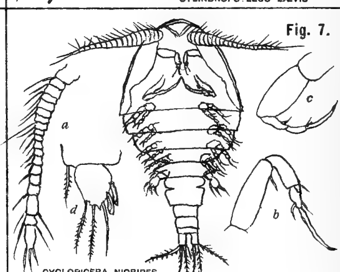


Fig. 7.
CYCLOPICERA NIGRIPES

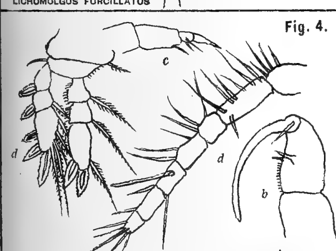


Fig. 4.
LICHOMOLGUS ~~ALBENS~~ agilis

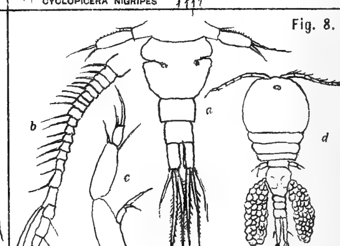
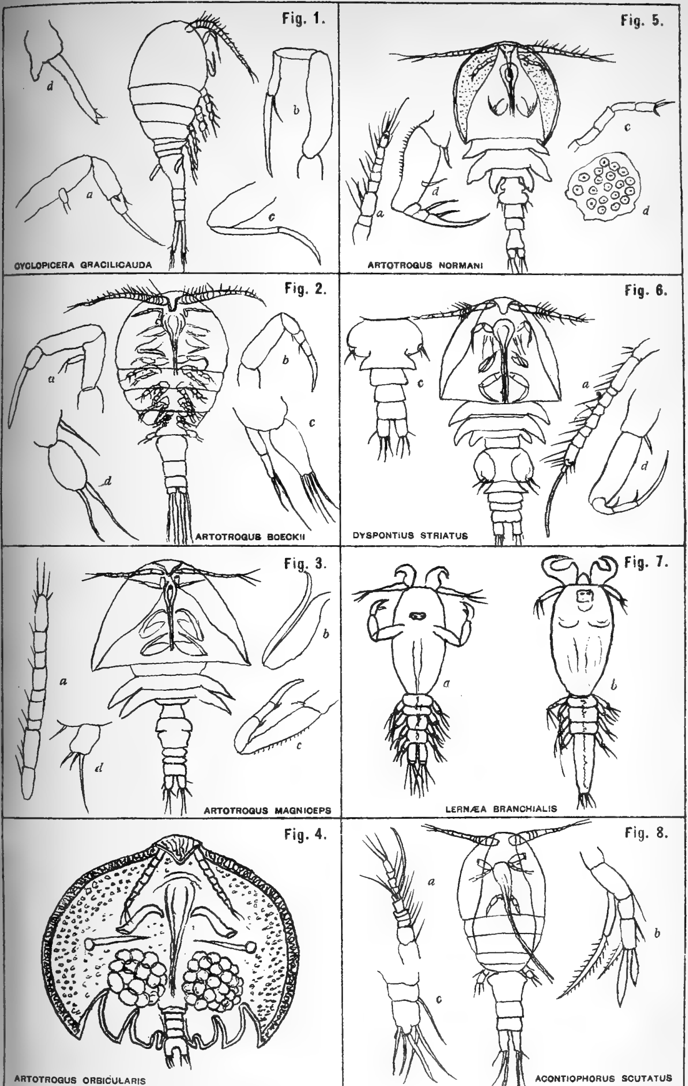


Fig. 8.
CYCLOPICERA LATA
LICHOMOLGUS AGILIS

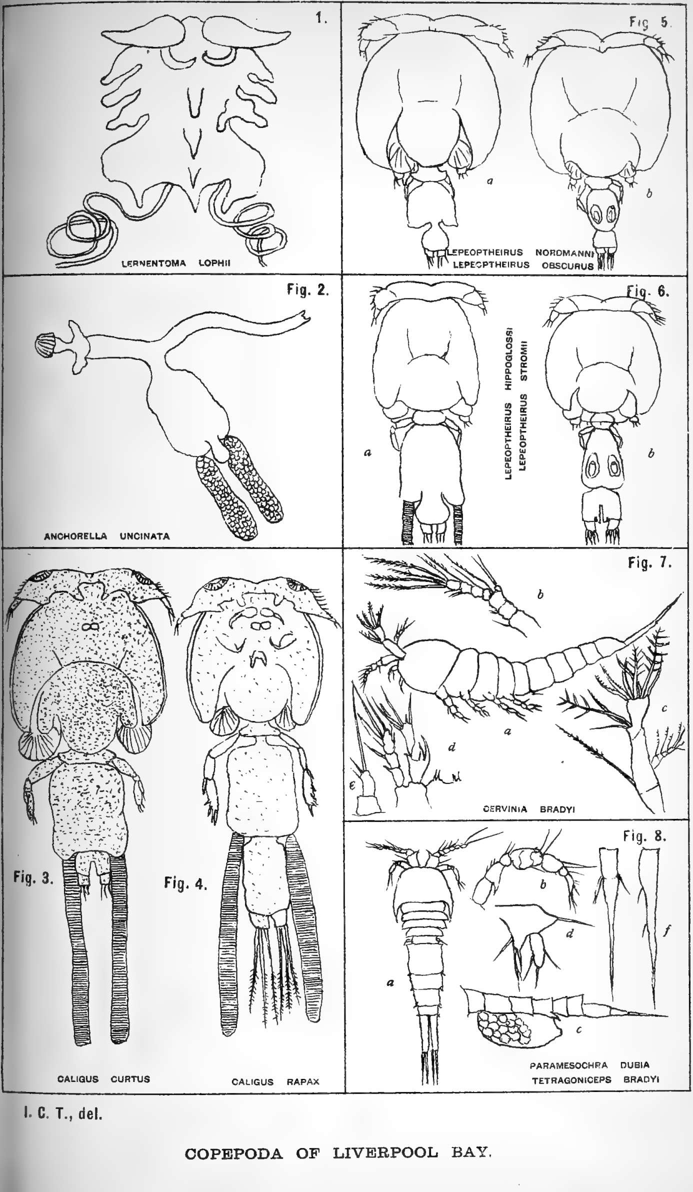
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



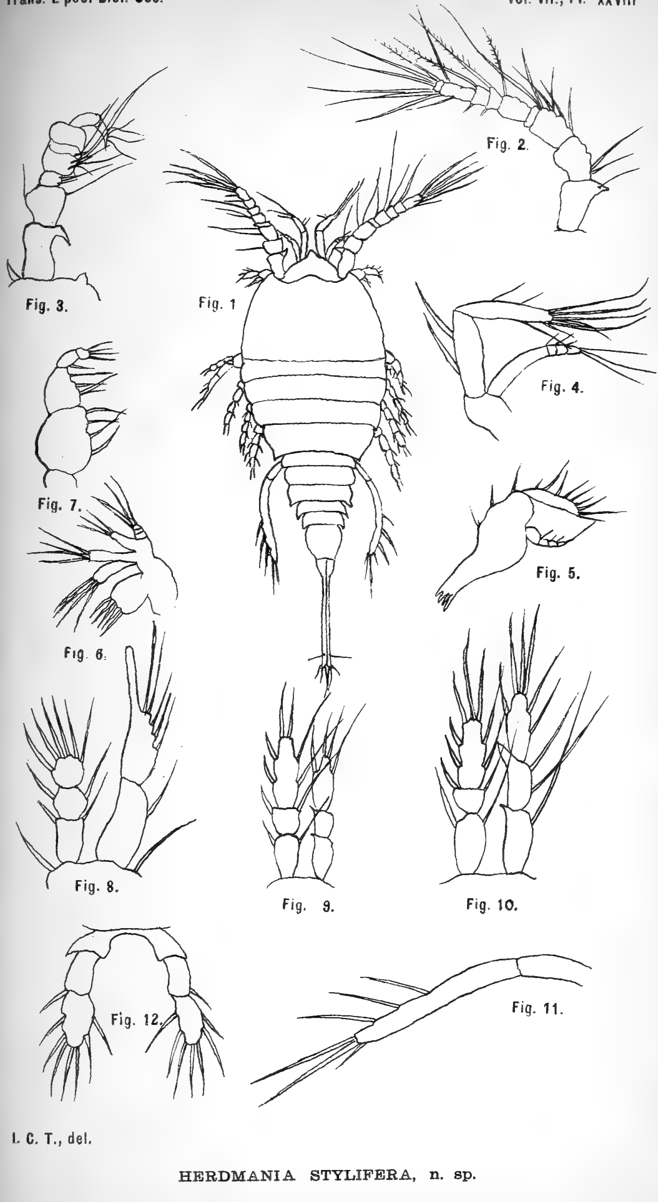
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



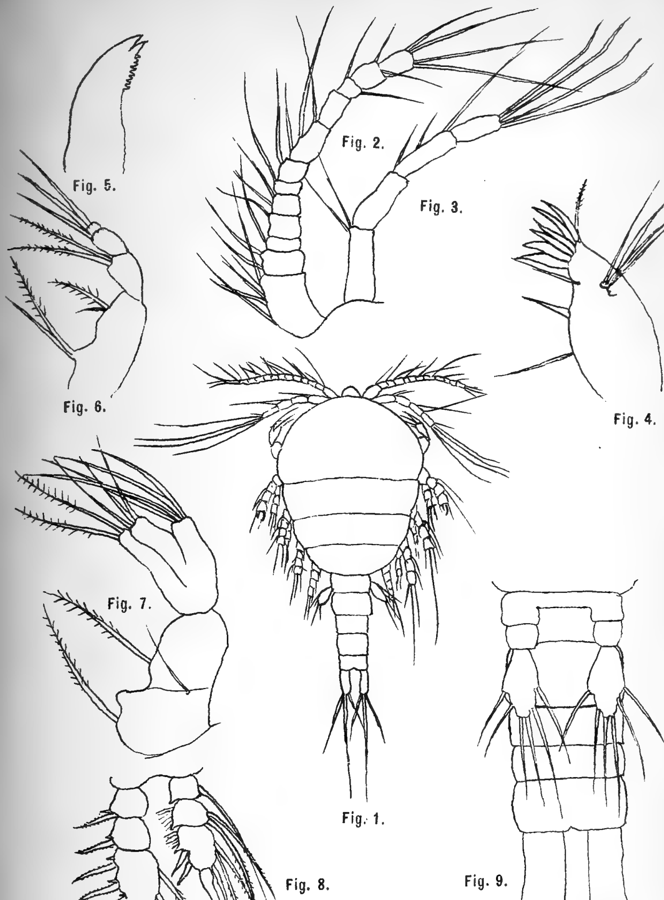
I. C. T., del.

COPEPODA OF LIVERPOOL BAY.



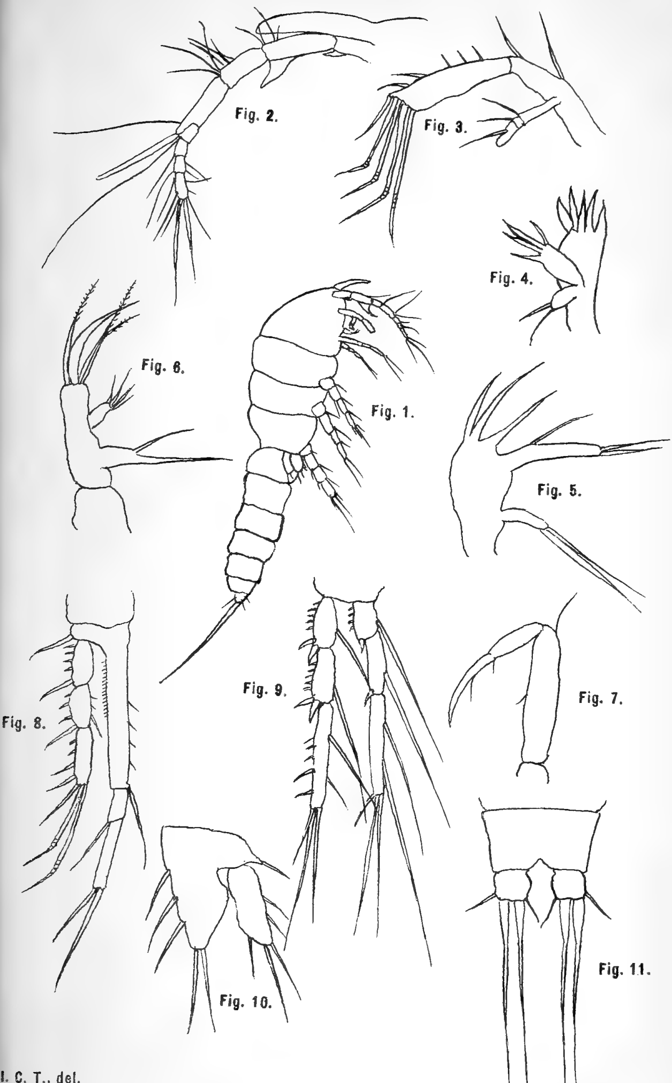
I. C. T., del.

HERDMANIA STYLIFERA, n. sp.



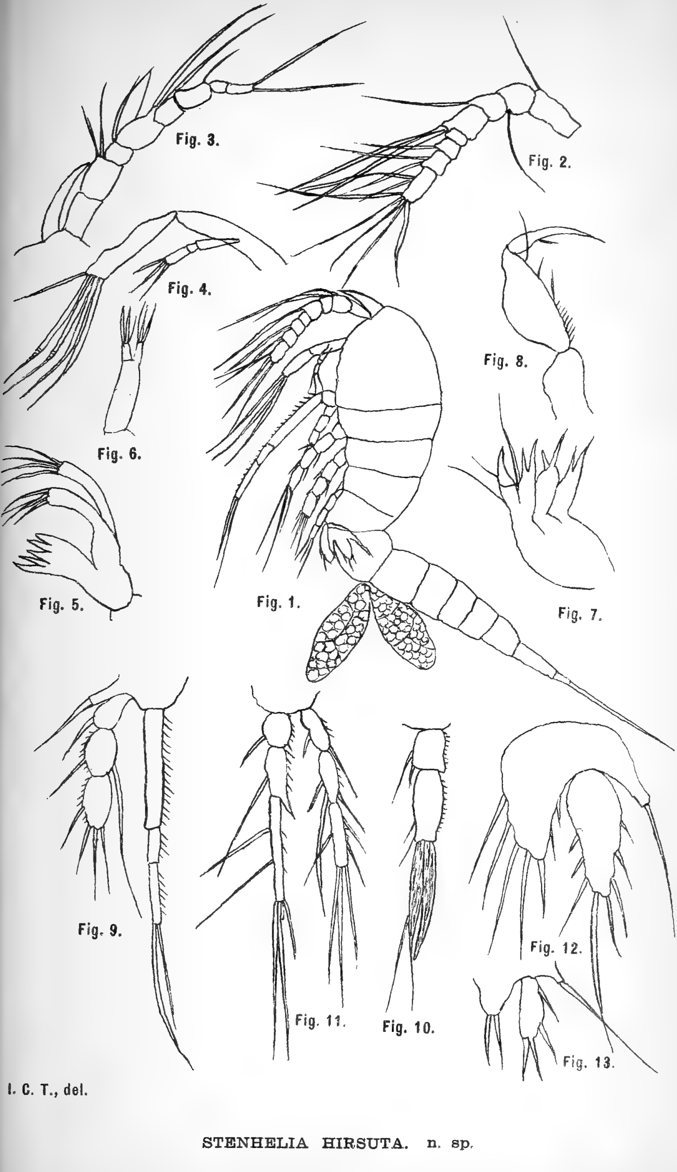
I. C. T., del.

CYCLOPS MARINUS. n. sp.



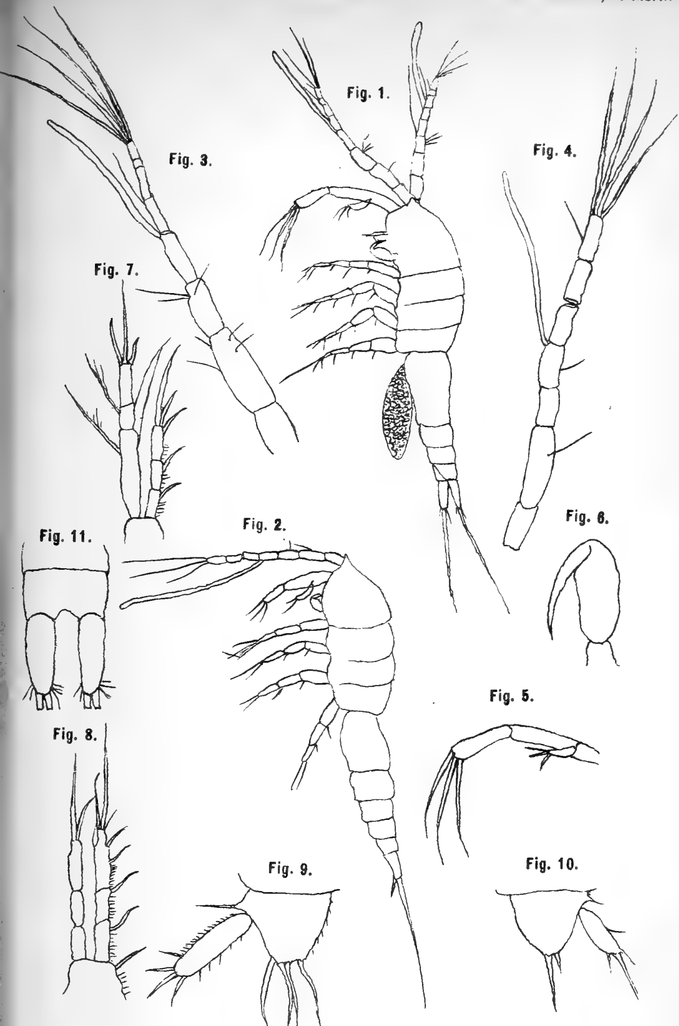
I. C. T., del.

STENHELIA DENTICULATA, n. sp.



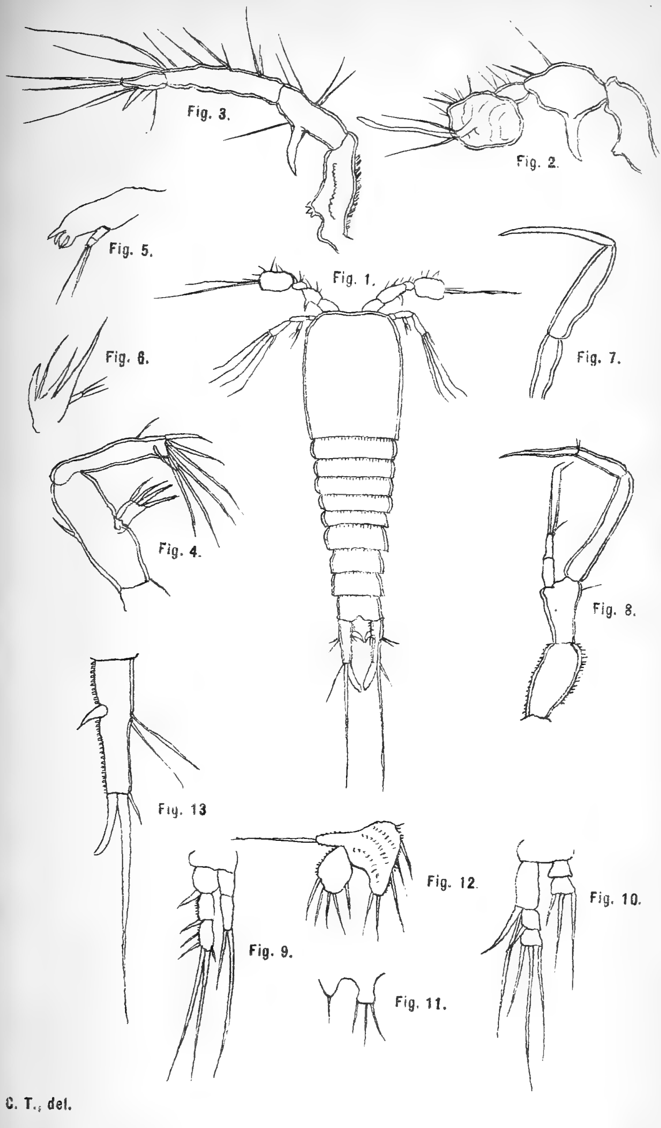
I. C. T., del.

STENHELIA HIRSUTA. n. sp.



I. C. T., del.

AMEIRA ATTENUATA, n. sp.



I. C. T., del.

LAOPHONTE SPINOSA, n. sp.

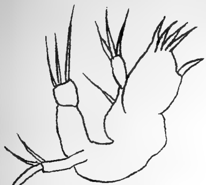


Fig. 5.

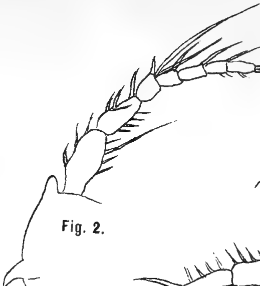


Fig. 2.

Fig. 7.

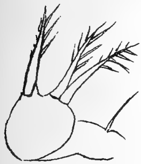


Fig. 6.

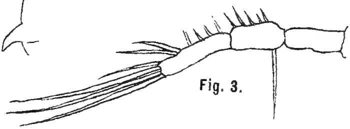


Fig. 3.

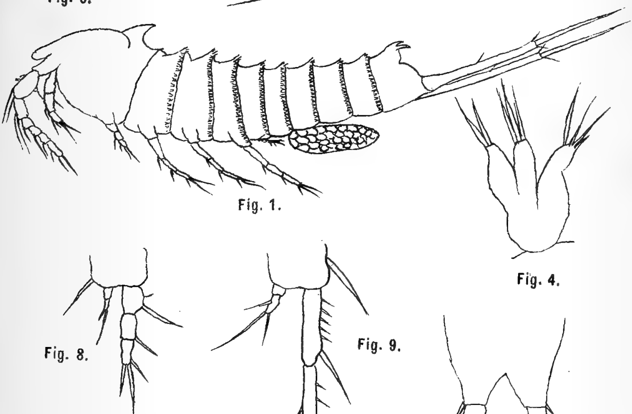


Fig. 1.

Fig. 4.

Fig. 8.

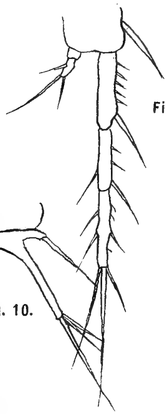


Fig. 9.

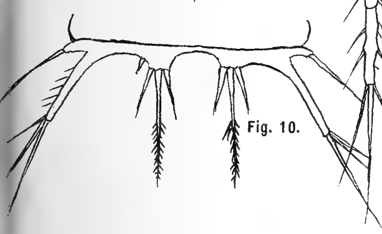


Fig. 10.

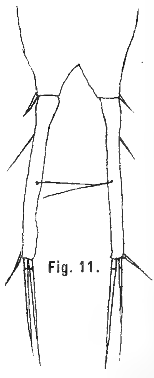
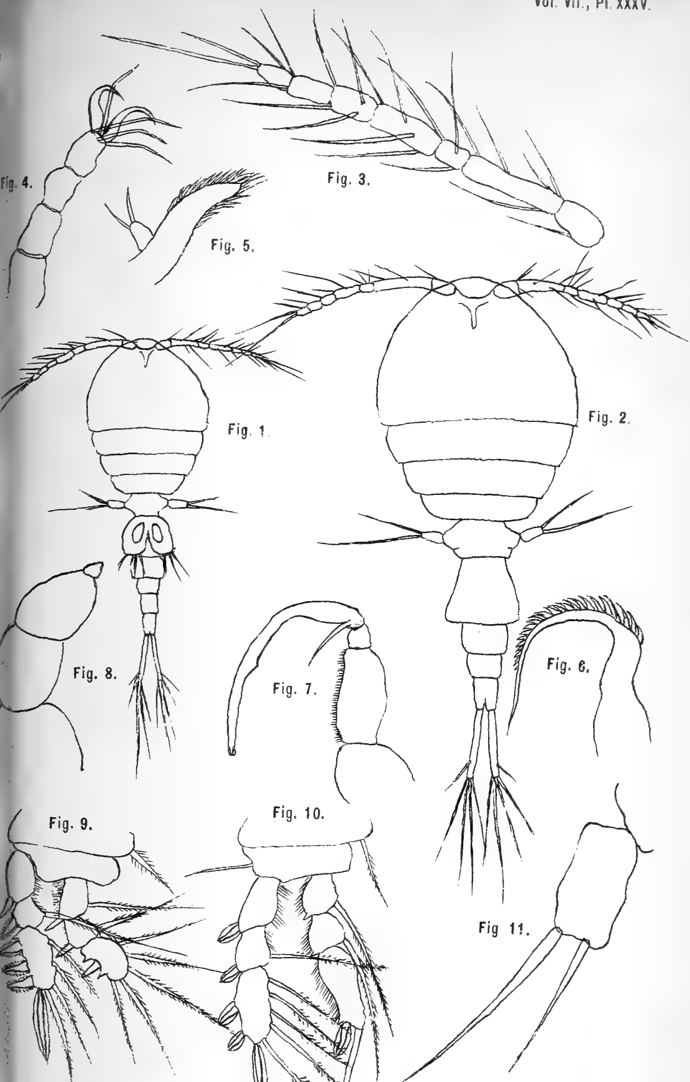


Fig. 11.

T., del.

CLETODES MONENSIS, n. sp.



LICHOMOLGUS MAXIMUS, n. sp.

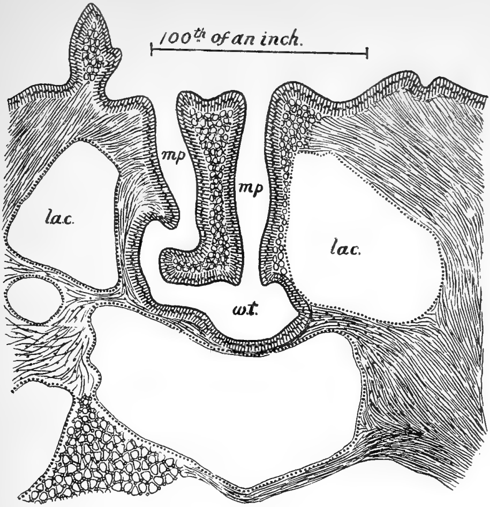


Fig. 1.

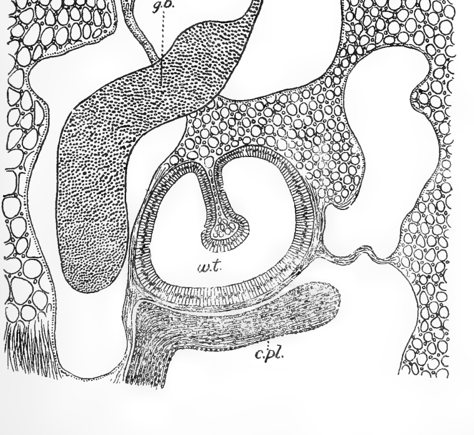


Fig. 2.

H. C. C., del.

ASTEROIDEA.

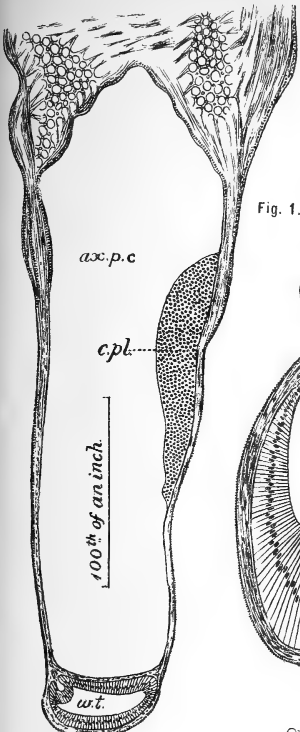


Fig. 1.

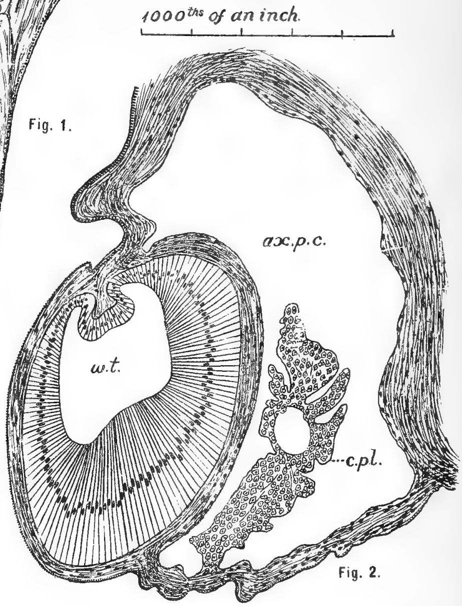
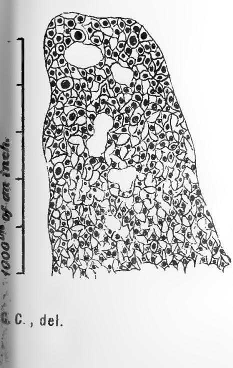


Fig. 2.

Fig. 3.



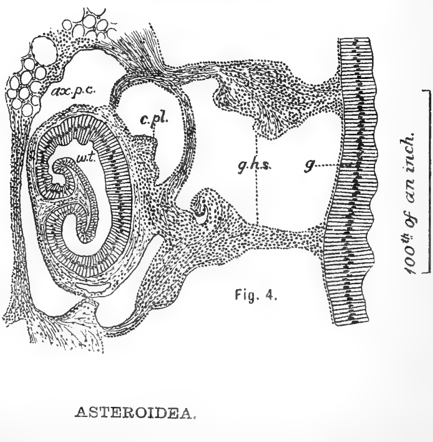
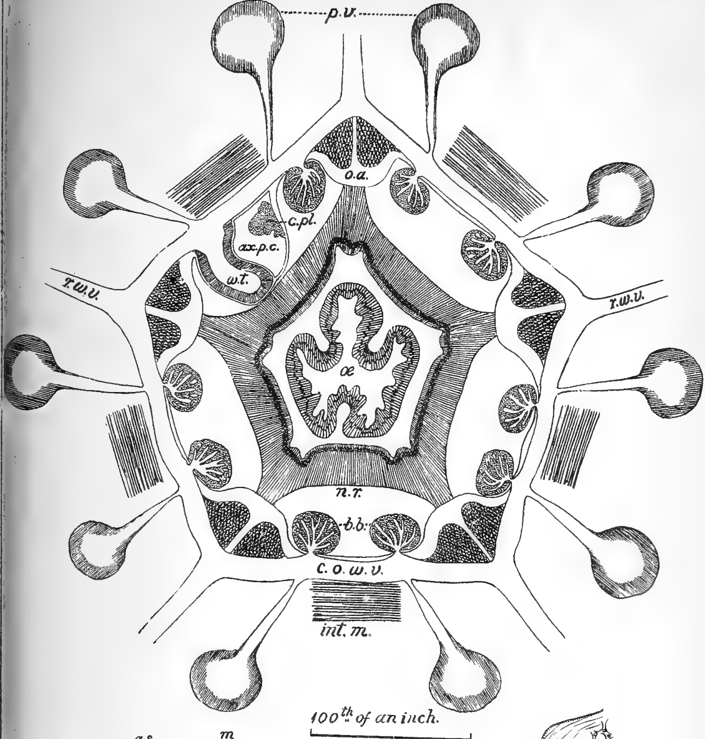


Fig. 4.

C., del.

ASTEROIDEA.

Fig. 1.



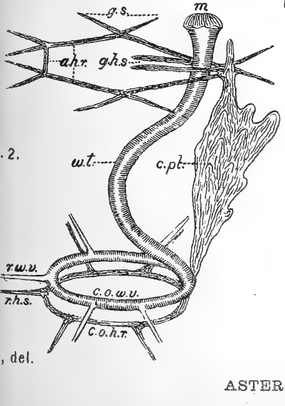


Fig. 2.

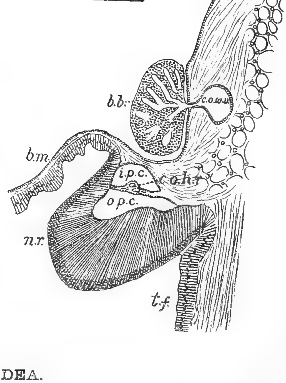
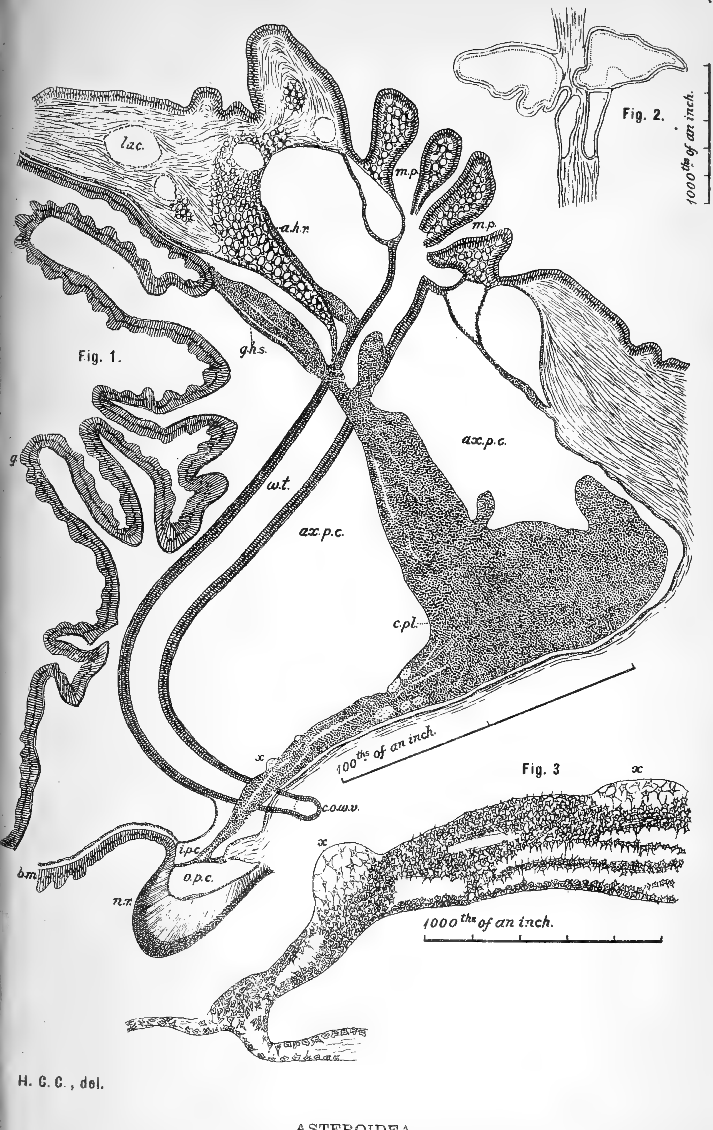


Fig. 3.

C. C., del.

ASTEROIDEA.



H. G. C., del.

ASTEROIDEA.